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Agricultural Research Practice for Environmental Management and Poverty**Reduction: the case of CIAT****PhD Thesis****An Interdisciplinary Research Project**

Submitted: 30 September 1997

In memory of NMR, 'beloved comrade'

Author no: M7164584

Date of submission: 30th September 1997Date of award: 8th October 1998

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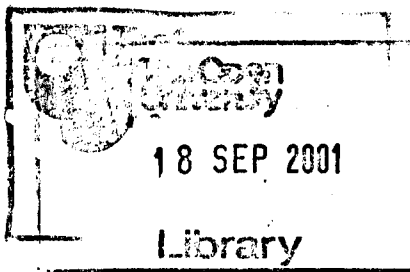
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Finally, I would like to acknowledge my debt to Erik Millstone, whose inspiring teaching at the Science Policy Research Unit first awakened my interest in food policy.



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Abstract

This thesis is about the institutions that apply developed-country science and technology to agriculture in underdeveloped countries. It considers the extraordinary series of changes in food production that has come to be known as the 'Green Revolution', arguing that the (less than ideal) outcomes of these changes reflected the characteristics of a particular network of research institutions known as the CG System, as mediated by the agricultural technology developed by the latter. Drawing on recent developments in the theory of innovation, the thesis argues that the characteristics of the CG System responsible for the outcomes of the 'Green Revolution' may be derived from the 'linear' model of innovation, upon which the former was apparently predicated. This 'linear' model of innovation is critically compared with a rival 'fifth generation' model. It is suggested that if the CG System were to adopt an innovatory practice that conformed to the 'fifth generation' model, it would enable itself to make a greater impact upon poverty and hunger. The reforms that are now being experienced by the CG System are critically considered in the light of this discussion. This argument is supported by empirical material which demonstrates that CIAT (a member of the CG System) has traditionally approached innovation in a manner consistent with the 'linear' model. However, an initiative based within CIAT's Hillside Programme is examined in detail and shown to be an attempt to introduce into this institute an innovatory practice consistent with the rival 'fifth generation' model. Formidable organisational forces act to resist this initiative and the changes that it seeks to effect in its organisational environment. Nonetheless, considerable movement towards the 'fifth generation' model is discerned at each of the different levels of analysis employed in the thesis, which concludes that this process of change is itself worthy of serious investigation.

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List of Abbreviations

América	Latin America
AR	Agricultural Revolution
BT	Biotechnology
CIAL	<i>Comité de Investigación Agropecuario Local</i> (Community Committee for Agricultural Investigation)
CIAT	<i>Centro Internacional de Agricultura Tropical</i> (International Centre for Tropical Agriculture)
CGIAR	Consultative Group on International Agricultural Research, also abbreviated as CG System
CIMMYT	<i>Centro Internacional de Mejoramiento de Maiz y Trigo</i> (International Centre for improving Maize and Wheat)
CIP	<i>Centro Internacional de la Papa</i> (International Potato Centre)
CIPASLA	<i>Consortio interinstitucional para una agricultura sostenible en laderas</i> (Inter-Institutional Consortium for Sustainable Hillside Agriculture)
DG	Director General
FEBESURCA	<i>Federación de Beneficiarios de la Subcuenca de Cabuyal</i> (Federation of Beneficiaries in the Cabuyal sub-basin)
FSR	Farming Systems Research
GIS	Geographical Information System
GTZ	<i>Deutsche Gesellschaft für Technische Zusammenarbeit</i> , the German technical agency for international cooperation
IARC	International Agricultural Research Centre
IDRC	International Development Research Centre
IFPRI	International Food Policy Research Institute
IIA	<i>Instituto de Investigaciones Agropecuario</i> (Agricultural Research Institute)
IITA	International Institute of Tropical Agriculture
IPM	Integrated Pest Management
IPP	Inter-Programme Project

IPRA	Participatory Research for Agriculture
IRRI	International Rice Research Institute
LDC	Less-developed Country
LRA	Low Resource Agriculture
MAP	Mexican Agricultural Project
MVs	Modern Varieties (of crops)
NARS	National Agricultural Research System, often also referred to as national programme
NGO	Non-Governmental Organisation
NRM	Natural Resource Management
PPO	<i>Planificación por Objetivos</i> (Planning by Objectives)
RF	Rockefeller Foundation
RPF	Resource-Poor Farmer
SENA	<i>Servicio Nacional de Aprendizaje</i> (National Training Service)
TAC	Technical Advisory Committee
TVs	Traditional Varieties (of crops)
UMATA	<i>Unidad Municipal de Asistencia Técnica Agropecuaria</i> (Municipal Unit for Technical Assistance to Agriculture).

Introduction

This thesis is about the institutions that apply developed-country science and technology to agriculture in underdeveloped countries. It considers the extraordinary series of changes in food production that has come to be known as the 'Green Revolution', arguing that the (less than ideal) outcomes of these changes reflected the characteristics of a particular network of research institutions known as the CG System, as mediated by the agricultural technology developed by the latter. Drawing on recent developments in the theory of innovation, the thesis argues that the characteristics of the CG System responsible for the outcomes of the 'Green Revolution' may be derived from the 'linear' model of innovation, upon which the former was apparently predicated. This 'linear' model of innovation is critically compared with a rival 'fifth generation' model. It is suggested that if the CG System were to adopt an innovatory practice that conformed to the 'fifth generation' model, it would enable itself to make a greater impact upon poverty and hunger. The reforms that are now being experienced by the CG System are critically considered in the light of this discussion. Considerable movement towards the 'fifth generation' model is discerned at each of the different levels of analysis employed. However, such changes are apparently resisted by formidable organisational forces.

The 'Green Revolution' and its limitations

Our starting point, then, is the 'Green Revolution'. This, together with the electrification of the Soviet Union, was surely among the most ambitious *deliberate* efforts ever made to employ science and technology to effect rapid structural change. The scale of its results were impressive: by the end of the 1980s, food production had doubled or trebled in many areas planted with 'Green Revolution' crop varieties (known as Modern Varieties, or MVs), while these varieties were cultivated by perhaps forty per cent of the rural population of the developing world. However, this dramatic increase in food production has not had a commensurate impact upon poverty and malnutrition: indeed, it "has not *sufficed* to improve poor people's food intakes much" [Lipton and Longhurst 1989, p3].

Such an outcome runs counter to the natural (and widely held) assumption that increased and more stable food production would mean less poverty and hunger, and therefore

requires explanation. Indeed, a vast literature devoted to resolving this apparent paradox has been produced over the last quarter of a century. On the whole, the disappointing outcomes of the 'Green Revolution' have been explained in terms of a poor match between the characteristics of the technology and the circumstances of the poor people for whose benefit it had ostensibly been developed: the 'circumstances' considered have included the agro-ecological environments of the land farmed by many poor people; the characteristics of the factor and product markets in which poor farmers need to participate, and of the labour markets through which the landless and those with inadequate land-holdings must earn at least part of their livelihoods.

As the above list of 'circumstances' may suggest, the rural poor are composed of several analytically distinct groups. The 'Green Revolution' affected the various groups in different ways. Consumers with low non-agricultural incomes almost certainly benefited from the decline in real prices that resulted from increased food production. However, the new technology did not adequately address the needs of poor producers within the regions where the MVs were introduced, and completely failed to address the needs of Resource Poor Farmers (RPFs) in Low Resource Agriculture (LRA). The consequent failure of MVs to diffuse into such agro-climates has resulted in greater regional inequality, particularly when farmers there have faced lower prices resulting from the increased output in MV-adopting areas.

This thesis will concentrate upon the relationship between agricultural research and resource-poor farmers. There are a number of reasons for this choice of focus. As will be argued in the second chapter, the changes in research practice that would enable the CG System (and comparable institutes) to address the needs of resource-poor farmers are precisely the same as those required for it to respond effectively to the degradation of the natural resource base. These changes, it will be argued, would also permit a more adequate response to the circumstances of poor producers in the areas where MVs have been adopted. Finally, while agricultural labourers in MV areas are probably more numerous than resource-poor farmers, the latter disadvantaged group is too large to ignore, including as it does the many people who depend upon 'remote' agro-climates or crops for which no suitable MVs are available. For Greeley and Joffe [1987], such 'remote' areas are characterised by "poorly developed infrastructure, little effective demand for or access to

purchased inputs, absence of reliable and developed water supplies, and highly heterogeneous agro-climates. These areas include most of sub-Saharan Africa, remote areas of Asia and Latin America, many upland areas, and humid forested areas everywhere.” In addition, Chambers *et al* [1990, p xviii] note that these areas are often “undulating and with fragile or problem soils” and provide the setting for a style of agriculture that is “complex in its farming systems, diverse in its environments, and risk-prone”.

The central issues to be considered, then, concern the reasons for the failure of agricultural research to respond adequately to the needs of low-resource agriculture. This failure will be explained in terms of the inappropriateness of that theory of innovation upon which the CG System is predicated. Reliance upon this theory, it will be argued, has resulted in a set of institutional arrangements that render the System incapable of serving low-resource agriculture. An alternative ‘fifth generation’ model of innovation will then be used to consider the kinds of institutional change that are necessary if this defect in the System is to be corrected. A discussion of the reforms that the System is now experiencing will then be used, both to clarify the relationship between change in the model of innovation practised by an organisation and wider organisational change, and to identify factors that may obstruct both kinds of change.

Three Controversial Propositions

The following propositions summarise some of this author’s conclusions from the ‘Green Revolution’ experience. While their truth may not be universally acknowledged, they have sufficient well-informed support to render further argument superfluous and will therefore be treated as axioms for the remainder of this thesis.

- (i) The circumstances of the poor (as listed in the preceding section) represent the proximate cause of most of the poverty and hunger under consideration;
- (ii) these ‘circumstances’ in turn reflect the power relations in which poor people are forced to participate;
- (iii) technology, in itself, can change neither these ‘circumstances’ of poor people nor the social relations that give rise to them.

It is tempting to conclude from these propositions that technology is of little relevance to the problem of poverty, and to concentrate instead upon the agency of the poor, and upon whatever other social phenomena appear able to change the power relations that are seen as being the fundamental cause of poverty. However, such a view ignores the fact that “[m]ajor technical transformations do not simply slot into old social realities, but are used by — and affect the power and options of — the groups of people who make those realities” [Lipton and Longhurst 1989, p9]. In particular, new technologies that possessed characteristics appropriate to the circumstances of the poor would represent an important resource for them, enabling them to exercise their agency more effectively and thus to modify the social relations responsible for their poverty. Such an outcome, while falling far short of the revolutionary transformation that is required by the most elementary principles of justice, remains preferable to the desperate immiseration that has followed the defeat or co-optation of popular movements in many arenas of the class struggle. This author therefore sees the development of agricultural technologies that are appropriate for poor people as a goal that is worthwhile, although inadequate. The first task of this thesis is to explain why, in the four decades that have elapsed since firm plans were made for the first International Agricultural Research Centre (IARC), even this inadequate goal has not been completely met.

Theories of Innovation and the CG System

This thesis will argue (Chapter 1) that the characteristics of any technology reflect innumerable conscious and unconscious choices made throughout the course of its development by the researchers responsible. Of course, these choices are constrained by such factors as the extent of the scientific and technical knowledge available to the researchers (which limits the options that are technically feasible), by the wishes of those able to influence the researchers (perhaps by controlling resources), and by the resources available for the development of any given technology. It follows from this that if we are to understand (and perhaps correct) the reasons for the poor match between MV technology and resource-poor farmers, we need to examine the institutes that developed this technology. Institutional issues concerning the ease of communication between the ‘domains’ of science and of low-resource agriculture are relevant here, as are the cognitive factors that determine the ability of researchers to comprehend the needs of their clients.

As a necessary prelude to our examination of the CG System, the first chapter begins by examining the theory of innovation that is apparently embodied in the CG System. This 'linear model' of innovation has received considerable critical attention: the main criticisms that have been made of it are reviewed and found to be justified. These criticisms provide the basis for formulating an alternative 'fifth generation' model of innovation. It is argued that the prescriptions of this latter model provide a more reliable guide to innovating effectively than those of the 'linear model', particularly when researchers lack *a priori* knowledge of their clients' needs. An immediate corollary of this view is that institutions whose design is predicated upon the 'linear' model are likely to be less effective innovators than those that embody the 'fifth generation' model, and that this difference in performance will be especially marked when client requirements are not apparent to researchers.

The remainder of the thesis examines the CG System in the light of the above theoretical discussion. A very close conformity is demonstrated between the prescriptions of the 'linear' model and the structure of the CG System. However, this thesis also describes considerable efforts to work in a manner far closer to the 'fifth generation' model that were made at various levels of the CG System. The thesis analyses such efforts made at the level of the entire CG System (chapter 2); at that of an individual IARC (chapter 3); and at the level of a research team within an IARC. The contradictions that, at each level, resulted from these efforts to work in a 'fifth generation' manner within a 'pipeline' type structure are analysed, and the thesis concludes that any change in the style of innovation practised by an organisation requires wider organisational change if it is to be effective.

Methodology

Thinking about Complexity

The reader may question whether the issues outlined above can feasibly be explored by empirical research. Not only are the systems considered large, varied, and geographically dispersed, but the issues explored concern each system *in relation to the others considered*. Thus, for example, it is not enough simply to investigate changes in the composition and working practice of a research team: these changes need to be related both to the farmers who will eventually use the technology developed, and to shifts in the organisational environment of the research team. Equally, organisational and policy changes at the level of the Research Centre and the entire CG System must be analysed in terms of the (often unexpected and sometimes perverse) developments that resulted at the level of the research team. While numerous studies of innovation and of organisational and technical change have been conducted at each of these epistemic levels, I am not aware of any earlier work that has concentrated upon the systemic linkages between each of these levels.

In order to undertake this task, I needed to define the boundaries of the study at each level with care, and to use three of the fundamental concepts of Systems theory in order to understand the ways in which developments at each level might be linked. Systems theory offered an particularly appropriate tool for this purpose, representing as it does a sustained effort to make sense of complexity. The three concepts that I found particularly valuable were those of *wholes*, *hierarchy* and *emergence*. These ideas owe their early formulation to biologists, perhaps because biological phenomena are of a complexity which has severely tested scientific method. Biologists have therefore been among the pioneers in establishing ways of thinking in terms of wholes, thus placing themselves within a tradition as old as the thought of Aristotle.

Aristotle had argued that a whole was more than the sum of its parts, and thus exhibited an innate purpose that was not apparent in its constituents. This doctrine, as applied to living things, was for Checkland [1981] the foundation of the modern science of biology.

Consistent with this Aristotelian view is the belief, held by members of the *organismic* school of biology, that the organism is an irreducible object which cannot be explained away by a purely analytical approach. Such organisms are characterised by *the definite*

organisation that they exhibit: indeed, a leading organicist suggested that such organisation “is the clearest and indeed the only decisive distinguishing feature between the vital happenings and the ordinary physico-chemical processes” [Von Bertalanffy, quoted in Checkland 1981 p77].

Organismic thinking was later generalised into thinking concerned with *wholes* in general, with the concept of organised complexity becoming the subject matter of the new ‘systems’ discipline which resulted. For Checkland [1981 p78], “the general model of organised complexity is that there exists a hierarchy of levels of organisation, each more complex than the one below, a level being characterised by emergent properties which do not exist at the lower level. Indeed, ... emergent properties are meaningless in the language appropriate to the lower level.” Rather, the processes which operate at the lower levels of complexity “result in an outcome which signals the existence of a new stable level of complexity ... which has emergent properties” [*ibid*]. Emergent properties, then, “stem from consideration of a system as a whole rather than as a mere aggregation or simple sum of the properties of individual parts” [Fortune 1993 p7].

The classic philosophical exposition of the principle of *emergence* is that presented by Broad in *The Mind and its Place in Nature*, published in 1925. Broad argues that any distinguishable whole must have “some special attribute” and that this attribute identifies “the characteristic behaviour of the whole [which] could not, even in theory, be deduced from the most complete knowledge of the behaviour of its components ...” [Broad, quoted in Hughes and Bignell, 1996 p3]. Broad thus emphasises the idea of unpredictability *from the characteristics of components*. A corollary of this idea is that “the existence of organisms having properties as wholes calls for different levels of description which correspond to different levels of reality” [Checkland *op cit*]. An immediate methodological conclusion, presented in Woodger’s *Biological Principles* of 1929, is that “an entity having the hierarchical type of organization such as we find in the organism requires investigation at all levels, and investigation of one level cannot replace the necessity for investigations of levels higher up in the hierarchy” [Woodger, quoted in Checkland 1981 p79].

Modern Systems Thinking

The ideas reviewed above have now been re-cast in a more abstract form, and provide a common thread linking the diverse work of those who now choose to describe themselves as Systems Thinkers. The members of this group tend to use the words *system* or *holon* to denote the abstract notion of a whole. A system, then, is a subjective ordering of reality — the result of a private decision to impose order on the observed world. More formally, a system is *an assembly of components* that (i) are connected together in an organised way; (ii) does something (as an assembly); and (iii) has been identified by a person as being of interest. For Ackoff [1981, quoted in Open University 1996 p50], a system “is a whole that cannot be divided into independent parts. From this, two of its most important properties derive: every part of a system has properties that it loses when separated from the system, and every system has some properties — its essential ones — that none of its parts do.” For Ackoff, such *emergent properties* of a system “derive from the *interactions* of its parts, not their actions taken separately. Therefore, *when a system is taken apart it loses its essential properties.*” He notes that one practical consequence of this observation is that: “If each part of a system, considered separately, is made to operate as efficiently as possible, the system as a whole will *not* operate as effectively as possible.”

Now, a system may be affected by entities that have not been included as components of the system itself. Those things which are not part of a system, but which can affect the system or be affected by it, are said to constitute its *environment*. A system is separated from its environment by its *boundary*: a subjective ‘line’ which need not correspond to any real-life barrier but simply marks the distinction made by an observer between the system of interest and its environment. The placing of the boundary of a system thus depends upon the observer’s judgement, and generally reflects the reasons why that system has been identified as being of interest. What should be clear is that the decision where to ‘draw’ the boundary of the system of interest will have a profound effect upon the subsequent analysis of the behaviour of that system.

The boundary of a system does not, in general, isolate it from its environment. On the contrary, the environment of a system has been defined as consisting of those entities that may affect the system of interest and thus alter its behaviour. Any system, then, may be subjected to different kinds of ‘shocks’ from its environment. If it is to continue to maintain

its separate existence within its environment (i.e. if it is to constitute what Beer [1985] calls a *viable system*) then it must be able to take adaptive action in response to environmental shocks and thus regulate itself. For Checkland [1991], it is the processes of *communication* and *control* that enable such adaptive action.

Central to the study of control is the principle of requisite variety. In its original form this states that any control system must be as varied and complex as the environment being controlled. This suggests that “the internal diversity of any self-regulating system must match the variety and complexity of its environment if it is to deal with the challenges posed by that environment” [Morgan 1986 p100], so that requisite variety is an important feature of living systems of all kinds, including both organisms and organisations. This means, as Morgan [*ibid*] points out, that “all elements of an organization should embody critical dimensions of the environment with which they have to deal ... [in order to] cope with the demands that they are likely to face”. This suggests that organisations should be built around “multifunctioned teams that collectively possess the requisite skills and abilities ... to deal with the environment in a holistic and integrated way”. I shall return to this point in Chapters 3 and 5 of the thesis.

Systems Thinking and the CGIAR

The structure of the thesis, then, reflects my application of the fundamental concepts of systems theory to the issues outlined earlier. Four distinct narratives are presented, unfolding at different epistemic levels but linked to each other by the concepts of *hierarchy* and *emergence*. The first chapter, located in the world of ideas, examines changes in the scholarly community’s understanding of innovation. This discussion outlines the theory that is apparently embodied by the CG System and then reviews the recent literature on industrial innovation, noting the repeated calls for the rapid and flexible formation of trans-disciplinary research teams and for user involvement in the innovation process. Indeed, these prescriptions represent an alternative model of innovation that, it is argued, could serve as the theoretical basis for a more effective research practice. However, it is argued that these prescriptions have profound organisational implications: organisations unwilling (or unable) to adopt a management structure and incentive system compatible with the new model of innovation are unlikely to be able to innovate successfully in the prescribed manner.

The thesis then considers three systems that are nested inside each other. The second chapter discusses the structure and performance of the CG System. Since this network of Research Centres played a leading role in the epic changes known as the 'Green Revolution', the importance of such a study must surely be apparent. In addition, this chapter argues that the CG System is an embodiment of the 'pipeline' model of innovation and therefore that both the successes and failures of the 'Green Revolution' illuminate the strengths and weaknesses of this theory. This chapter also considers the pressures now experienced by the CG System that are acting to change the model of innovation that it practices.

The third chapter examines the ways in which these changes are affecting an individual Research Centre within the CG System. Since the thesis as a whole is concerned with the transition towards a different model of innovation, the Centre chosen for investigation was CIAT, where these change processes have probably gone further, and have been implemented in a more profound fashion, than is the case elsewhere in the CG System.

The fourth and fifth chapters unfold at the fourth level of analysis, that of a particular research group within CIAT. Again, this group was chosen because it had carried the changes further and implemented them in a more comprehensive fashion than was the case in other parts of CIAT. While the fourth chapter sets out the plans that this group had made for its work, the fifth chapter considers the actual events that took place when these plans were implemented and thus came up against the realities of the wider organisation. This experience indicates the consequences of attempting to work in a manner that contradicts the assumptions upon which the 'host' organisation is predicated, consequences that are reviewed in the conclusion, which returns us to the world of theory.

Semi-structured Interviews

I conducted in-depth, semi-structured interviews with Principal Scientists attached to virtually all of CIAT's Programmes and Units. In most cases (particularly towards the end of my field research) the interviewee had been selected because I knew that s/he had taken part in an event that was of interest to me, or held an informed opinion about a particular issue. For this reason, most of the interviews were unique in the set of topics that they covered. While I began each interview with a clear idea of the areas that I wished to be covered, I endeavoured to allow each interviewee to lead the discussion and thus to convey their own perceptions. I also paid attention to the tone of voice and body language used, in this way seeking to identify sensitive issues that would require further investigation.

Interviews generally lasted for between one and two hours, although two interviews (punctuated by meals) lasted for as long as four hours. Most interviews were tape-recorded, although I chose not to use a tape recorder for some interviews, either when I was anxious to create an informal and free-flowing atmosphere or when I knew that particularly sensitive topics were to be covered. Whenever a tape-recorder was used, it was placed with the controls within reach of the respondent, who was invited to turn it off at any point if s/he felt that the conversation was too sensitive to be recorded. This invitation was accepted on several occasions.

All interviewees were offered the opportunity to remain anonymous: only a few chose to exercise this option. Interestingly, the anonymous interviews did not yield usable information: comments made under these circumstances were contradicted by information gathered in other ways and from other informants. Another consideration was that the value of any statement depends greatly upon the identity of the person making it. In an organisation where the flow of information is controlled, and where perceptions and interests vary between different parts of the organisation, it is important to establish (i) that any informant was in a position to know about the issues discussed, (ii) the particular perspective held by the informant on the topic in question. For this reason, informants are generally identified within the text by the position they held within CIAT. In some cases this was not practicable. Certain individuals held views that had been coloured by a whole series of positions that they had held: in these cases the name of the individual has been used. Names are also used in cases where confusion would have resulted had the position

been used (for example, two different people served as Leader of the Hillsides Programme during the period of my field research).

Since a whole series of interviews was conducted with people employed by the same organisation, and affected in different ways by the same events, it was possible to cross-check these accounts against each other and return to the informants to resolve apparent contradictions. It was also possible to 'triangulate' interview data with CIAT's published reports and with informal conversations; the latter mainly took place either within the Centre's cafeteria or in the many salsa bars and discotheques with which Cali is so well endowed.

Limitations of the Study

A relatively small-scale study such as this must be confined within firm boundaries. For this reason, a number of promising avenues of inquiry have not been pursued. Thus, discussion of CIAT's organisational characteristics has been restricted to those aspects that affect its capacity to alter the *style* of innovation that it practises; the views of CIAT staff presented here are, with just two exceptions, drawn only from discussions with members of the Principal Staff (accounting for less than 10 per cent of CIAT's employees); while little or no original data on the responses of farmers to the new technology developed by CIAT was collected by the present author.

Undertaking a complete organisational study of CIAT would certainly require several years. Such a study would certainly highlight those ways in which the characteristics of CIAT differ from those generally held (for example, by Dodgson [1991]) to favour the effective pursuit of innovation. Examples of these prevalent in the lower levels of most of CIAT, but not within the Hillsides Programme, are the rigid manner in which the tasks and responsibilities attached to each role in the organisation are defined; the near-obsession with secrecy; and the constant threat of punishment and personal humiliation for those known to have transgressed these norms. The hierarchical structure of CIAT is particularly striking, with its enormous gulf between the doctorally-qualified Principal Staff, who are trusted to manage their own workloads and exercise their own discretion, and the 'employees' who are expected simply to obey the orders given by their superiors.

My field research included numerous conversations with people employed at all levels within CIAT. Unfortunately, it was apparent that so little information had been shared with the 'employees' that they had not been able to form opinions about the issues that were of interest to me. An exception, of course, was the Hillsides Programme, the management of which was careful to involve all staff in discussion of major issues affecting the Programme.

Since the technologies considered in the later parts of this thesis are still undergoing development, only a limited number of rural people (those living in the project sites) have been exposed to them. These communities have already been over-researched by the many students and others attached to CIAT. This has given rise to some anxiety that the demands that have been and are made upon their time may reduce their willingness to collaborate with further research by CIAT. For this reason, I was discouraged from undertaking independent field research in the area. Instead, I accompanied CIAT social scientists on the visits they made, observing and sometimes participating in the research interviews that they conducted and the meetings that they organised. These activities were sufficient to convince me that the information given to me by the social scientists concerned was reliable, and that any field research that I could have conducted within the constraints to which I was subject was unlikely to result in any improvement upon the information already available to me.

Chapter 1 Understanding Innovation: from 'linear' to 'fifth generation' models

Introduction

This first chapter will outline explicitly the ideas that underlie the institutions that operated to generate the 'Green Revolution' technology. These ideas concern relations between scientific research and agricultural production and so may be placed within the evolving debate about innovation theory. A traditional way of setting out the issues around innovation is to postulate a division of labour between 'knowledge search' and 'knowledge use'. These categories are themselves often subdivided into a number of distinct 'stages', linked in a simple linear fashion. This conceptualisation will be subjected to a critical discussion. I will argue that the 'pipeline' metaphor often employed to illuminate this process also leads to dubious assumptions about the direction in which knowledge flows between these 'stages' and the nature of the communication that is involved; these in turn may lead to mistaken beliefs about the parts of this process which possess agency. Latour [1987] suggests reasons why this model is both compelling and misleading.

A different model of the innovation process, one that is both more satisfactory in conceptual terms and soundly based on a mass of empirical research, has been advanced by Dosi [1982]. This model will next be discussed. Some subsequent developments in the theory of innovation will then be considered briefly, after which an extended conclusion will draw out from this discussion the ideas most relevant to the project discussed in later chapters and will suggest that implementing innovative projects in the manner suggested by these ideas raises non-trivial organisational issues that have not yet received the attention that they merit.

The linear model of innovation

Origins of the linear model

Perhaps the earliest theory of technological innovation was that advanced during the scientific revolution by Sir Francis Bacon (1560-1626). As Kealey [1996] points out, it was Bacon who first advanced the familiar argument that since economic growth depends upon applied science, while applied science depends upon pure science, the funding of pure science by government is crucial to the creation of wealth. In fact, Bacon went on to advocate public support for pure science so that it could develop unhindered by practical considerations, and used a metaphor for knowledge that implied that it could be stored and moved in an unproblematic fashion.

Bacon's practical concern was not limited to economic growth, but embraced all dimensions of the power exercised by (some) human beings over nature — and (fundamental scientific) knowledge was the key to this power. Thus, in his manifesto-like work *The Advancement of Learning* (addressed to the king and first published in 1605) he argues that applied knowledge (he speaks of “professions”) is derived from more fundamental knowledge: “if any man think philosophy and universality to be idle studies, he doth not consider that all professions are from these served and supplied. And this I take to be a great cause that hath hindered the progression of learning, because these fundamental knowledges have been studied but in passage.” [Bacon 1906, p75] Thus, he believed that far more could be achieved if a more systematic study of “these fundamental knowledges” were to be undertaken. This view was eloquently expressed in his allegorical work *The New Atlantis*, in words that he places in the mouth of the high priest of ‘experimental philosophy’: “The End of our Foundation [scientific institute] is the knowledge of Causes and secret motions of things, and the enlarging of the bounds of Human Empire, to the effecting of all things possible” [quoted in Easlea 1981, p249].

An even stronger statement of this vision is presented in an unpublished work entitled *The Masculine Birth of Time*. Here, Bacon states that his “only earthly wish [is] to stretch the deplorably narrow limits of man's dominion over the universe to their promised bounds”. Addressing his words to a ‘son of science’, he represents himself as “leading to you Nature with all her children to bind her to your service and make her your slave” [Farrington 1964

p62]. The sexual imagery used in this and in many other contemporary passages suggested to Easlea [*op. cit.*] that their authors envisaged the scientific enterprise as a gang rape of Nature, and that the domination sought through science by these upper-class white men was not only over inanimate matter, but also over 'natural' people: namely men of backgrounds other than their own, and women of all backgrounds.

If pure science can deliver such fantastic benefits to (some) men, then it is important (for them at least) that the resources necessary for its development should be forthcoming. Addressing his monarch, Bacon [1906 pp73-4] used an original metaphor to make this point. He argued that, just as water had to be stored in deliberately constructed reservoirs if it were not to be dissipated, so "learning" required *institutions* "for the receipt and comforting of the same". Such institutions, he argued, should receive Royal support so that they should not be exposed to mundane (practical) concerns: on the contrary, he saw all forms of such support as "tending to quietness and privateness of life, and discharge of cares and troubles". Developing this theme, he went on to advance arguments (later to be well-rehearsed), both for adequate academic salaries;

it is necessary to the progression of sciences that readers be of the most able and sufficient men; as those which are ordained for generating and propagating of sciences, and not for transitory use. This cannot be, except their condition and endowment be such as may content the ablest man to appropriate his whole labour and continue his whole age in that function and attendance;

and for research funding;

there will hardly be any main proficience in the disclosing of nature, except there be some allowance for expenses about experiments; whether they be experiments appertaining to Vulcanus or Dædalus, furnace or engine, or any other kind. And therefore as secretaries and spials of princes and states bring in bills for intelligence, so you must allow the spials and intelligencers of nature to bring in their bills; or else you shall be ill advertised.

Bacon's ideas, advanced at the point when the establishment of scientific institutions was beginning, must inevitably have influenced the character of these nascent institutions. Indeed, as the first Secretary of the Royal Society Bacon himself was in a position to mould the character of this institution. While he presented the scientific institutions that he advocated as "directed to the improvement of the conditions of life by the discovery of new arts" [Farrington *op. cit.* p22], some critics have suggested that their purpose, more specifically, was to enhance the position of certain social groups *vis-à-vis* other groups: for

Martin [1992] Bacon's project was a means of augmenting the power of the state, and of the Crown within the state. These themes have continued to provide the agenda, even for modern debates about innovation.

The linear model in the twentieth century

Kline [1989] presents a simplified summary of the ways in which the process of innovation in industrial societies has traditionally been modelled by the members of various intellectual communities. He notes that most of the economists who have taken part in this discussion have stressed the role of market demand in "calling forth or inducing new inventions, products and processes" [*ibid* p6], citing the work of Schmookler [1966] (which correlated inventive activity and economic opportunity) and that of Myers and Marquis [1969]. Within the technical community, however, the view that innovations arise from the creation of new knowledge receives greater support: "Some scientists have argued that science is the primary driving force for innovative activity. This point of view has seldom been the basis for published journal articles, but the present writer has heard scientists take this view many times in public speeches." [Kline *op cit*, p6] However, he then notes the existence of a considerable volume of empirical evidence that fails to confirm either viewpoint.

Kline goes on to suggest a common cause both for this fundamental disagreement among serious scholars of innovation and for the lack of congruence between their work and the evidence available. His paradoxical suggestion is that these phenomena result from "the *implicit use* of [the same] inappropriate model of industrial innovation processes" [*ibid* p7].¹ The model in question, upon which both of the above viewpoints "seem to rest *implicitly*", is that known as the 'linear model'. He quotes Price and Bass [1969], in whose words the 'linear model' views innovation as "an orderly process, starting with the discovery of new knowledge, moving through various stages of development, and eventually emerging in a final viable form". Such a model, he argues, is assumed by both

¹ Although Kline does not attempt to resolve this paradox, it seems plausible that any attempt to analyse complicated data with a simple model will involve ignoring or discarding some of this data. Since (logically) the model itself cannot guide this selection process, it is likely to be performed in a manner that reflects the personal experience of the researcher in question. Thus, use of the same inappropriately simple model could lead researchers from different backgrounds to draw radically different conclusions from similar data sets.

‘science push’ and ‘market pull’ theories of innovation: “to have a push or pull implies a process with a beginning and end, and some kind of direct connection between them” [*ibid*].

Now, one peculiar feature of this ‘linear model’ is that none of the literature on innovation explicitly advocates it. On the contrary, Kline [*op cit*] acknowledges that the authors of the viewpoints he reviews, including Price and Bass, “are quite clear that they see the linear model as far too simple to be adequate”. However, many institutions and policies intended to promote innovation are crafted *as if* their architects believed in the ‘linear model’²: as Newby [1992, p11] puts it, this model “remains extremely difficult to dislodge in the minds of many senior science policy makers”. Kline states that this model “continues to underlie the thinking in many current speeches and much writing” and suggests that the very phrase ‘R & D’, commonly used to refer to innovation processes, itself implies a linear model by suggesting a direct path from research to development and production [*op cit* p7]. Thus, the ‘linear model’, at least as it has been presented in the literature (including those accounts reviewed below), appears to be a construct of its critics, intended to enable them to analyse in a critical fashion the implicit assumptions upon which policy appears to have been founded. The account that follows should be seen as lying within this tradition.

For Clark [1994] the foundation of the ‘linear model’ is the distinction made between ‘knowledge search’ and ‘knowledge use’. He outlines the relationship that the model postulates between the two sub-systems in the following terms. ‘Knowledge search’ is seen as taking place within publicly funded organisations that carry out pure research in accordance with norms of objectivity enforced by the cognitive authority of peer review. The knowledge that results from this activity is then drawn upon as and when needed by a market-driven productive sector of the economy in order to assist it in making money from the sale of goods and services.

It should be noted that these ‘knowledge search’ and ‘knowledge use’ sub-systems developed autonomously and with a considerable degree of independence from each other: for Price [1965] (cited by Freeman [1982]) they constituted different professions with

²See, for example, Massey *et al* [1992]; Henry *et al* [1995]; as well as the subsequent discussion of the CG System.

largely independent traditions. Historically, the primary concern of the scientific community was the discovery and publication of new knowledge in a manner that would satisfy its own professional criteria: the application of such knowledge was of lesser or no importance. Within the productive (knowledge-using) sector, however, practical application was of the first importance. Engineers and technologists thus secured professional recognition by demonstrating a working device or design, while publication was of negligible importance to them.

Despite the independent development of these two systems, neither Price nor Freeman deny that 'science' and 'technology' have interacted very powerfully with each other. The development of the steam engine stimulated the growth of thermodynamics, whilst scientific knowledge of electricity and magnetism provided a foundation for the electrical engineering industry. Perhaps the latter experience led to the widespread belief that it is advances in science that make innovation possible, or in other words that progress within the 'knowledge search' system is a necessary if not sufficient condition for the 'knowledge use' system to develop.

Another explanation for this belief is provided by Latour [1987 pp132-144], who demonstrates that it is a logical consequence of a widely-held (although in his view mistaken) set of ideas about the diffusion of facts and artefacts. Latour argues that "well-established facts" and "routinely-used pieces of equipment" are constructed by the formation of stable coalitions of human and non-human elements. Since each of these human actors has been convinced that their interests are served by use of the piece of equipment or belief in the 'well-established fact', they "will not even think of disputing the claims [or 'facts'], since this would be against their own interests ... Dissent has been made unthinkable." This state of affairs has two consequences. One is that the condition of belief blinds the believers to their own part in upholding that which is believed, and thus to any ways in which they themselves modify the facts or artefacts under consideration. The second follows immediately from this: "these people do not do anything more to the objects, except pass them along, reproduce them, buy them, believe them. ... As a result, claims become well-established facts and prototypes are turned into routinely used pieces of equipment. Since the claim is believed by one more person, the product bought by one more customer, the argument incorporated in one more article or textbook ... they spread

in time and space.” Thus, “it seems as if there are facts and machines spreading through minds, factories and households ... Spewed out by a few centres and laboratories, new things and beliefs are emerging, free floating through minds and hands, populating the world with replicas of themselves.”

Latour calls this description of “moving facts and machines” the diffusion model and points out that it leads to a number of surprising consequences. One of these follows from the believers’ denial that they modify the facts or artefacts under consideration, instead passively passing them on unchanged. In reality, however, facts and machines are constantly changing and are not simply reproduced. Explaining this inconvenient but undeniable observation within the diffusion model presents considerable difficulties, since this model posits that science and technologies are shaped only at the beginning. The model will only permit explanations of novelty that rely upon the initiators and so “the notion of *discovery* has been invented: what was there all along needs a few people, not to shape it, but to help it to appear in public”. Credit for the entire development and application of an idea is thus given to its original discoverer. Since the functioning of virtually any innovation may be described as a logical corollary of the scientific knowledge that explains it, the effect of the diffusion model is to direct attention towards the scientific community and to locate explanations of innovation within the ‘knowledge search’ system.

Latour presents the diffusion model in opposition to his own view, and so his description of it should be seen as a piece of (amusing) rhetoric rather than a serious theory. However, it does capture (and ridicule) widely held beliefs about the relationship between science and technology. The above account may therefore help to explain the widespread assumption that innovations originate with advances in ‘basic’ science, an assumption that underpins at least the uni-directional or ‘pipeline’ forms of the linear model of innovation.

According to this model, a productive sector draws upon knowledge produced by a ‘knowledge-seeking’ sector in order to provide and sell novel goods and services. Freeman [1974] is among those who point out that this division into only two sub-systems and types of activities is excessively simplistic. He disaggregates the activity of R & D into the following categories;

- (a) **Basic Research** — Creative work undertaken on a systematic basis to increase the stock of scientific knowledge. It is not primarily directed towards any specific practical aim or application. Sometimes a category called *strategic* basic research is distinguished to denote work in a field of present or potential scientific, economic or social interest.
- (b) **Applied Research** — Original research directed towards a specific practical aim or objective which may be predetermined. Sometimes the word is used to denote the articulation of basic research findings in practical form.
- (c) **Experimental Development** — The use of scientific knowledge in order to produce new or substantially improved materials, devices, products, processes, systems or services.

Clark [1994] describes this model of the innovation process in terms of “knowledge flows through a ‘pipeline’ which has basic research activity at one end and knowledge embodied as useful products at the other. At the basic research end resources are allocated to ‘basic’ science having only greater understanding of nature as its objective. Some of the resultant knowledge, however, has potential economic value and so further resources are ‘applied’ to this knowledge to enhance its technological power. Once the new technology shows good commercial promise resources are given to ‘develop’ the innovation to its ultimate commercial form.” Incremental technical change may take place subsequent to innovation since “new technologies are never static but rather evolve into new forms as a result of economic pressures over time”. The category of ‘strategic’ research may also be distinguished from ‘basic’ research “to take account of the existence of fundamental research which is nevertheless funded because it has some broad mission orientation”.

This description amounts to more than Freeman’s (uncontroversial) observation that innovations arise from the distinct yet functionally linked activities that he describes. The ‘pipeline’ metaphor leads the reader to make a number of questionable assumptions about the innovation process. Since flow through a pipeline is usually only possible in one direction, the impression is given that innovation is *caused* by basic research activities, and that the other activities make their contributions subsequently and in a rigidly defined order. Again, the pipeline image suggests that knowledge is a homogenous substance that may be ‘pumped’ along from one activity to the next in an unproblematic fashion, but this metaphor of communication is controversial, and probably conceals more of significance

than it reveals. In particular, by representing knowledge flows as automatic this model conceals the possibility that people engaged in these different innovative activities may experience communication difficulties. I shall return to these issues after outlining certain institutional consequences of this model.

The linear model of innovation, as Massey *et al* [1992: 60] make clear, has a number of necessary social implications. The first of these is that “the linear sequence of activities implies a parallel *division of labour*; there is a sequence of different groups of people performing the successive tasks. Second, this is an intrinsically *relational* model. That is to say, each link in the chain is defined by and necessarily entails links with the upstream and downstream activities. Each element, for its existence, its purpose, and its very definition, is dependent on the other links in the chain. Third, and putting these two characteristics together, it is a relational division of labour with a distinctly *hierarchical content*.” Now the diffusion model (as outlined by Latour) stresses the achievement of the original discoverer and represents subsequent development and production as essentially passive, quasi-automatic activities. In terms of the linear model, it represents a powerful argument for concentrating attention and status upon the basic science end of the ‘pipeline’, since only this point is seen as having agency. Remembering that the diffusion model represents an attempt at explicit presentation of widely-held but rarely articulated beliefs about innovation, it is not surprising to find this “classic model of the separation of conception from execution” implicit within the linear model. The prediction made by the diffusion model, that only activities close to basic science have agency while subsequent development is quasi-automatic, is now seen to be a self-fulfilling prophecy.

Clark [1994] highlights some interesting normative consequences of this separation of conception from execution. Conception is seen as being the responsibility of ‘basic’ research, an activity whose outputs have no commercial value but are public goods and should therefore be financed collectively. This usually means that such work is financed publicly, and so is most easily organised if it is performed within a public-sector research institute. An additional argument for this state of affairs is that by tradition only scientists are believed to possess the necessary understanding of the subject to judge the value of basic research. Since the requirements of the market are not deemed relevant to such

judgements, any attempt to perform basic research *conceptualised in this way* within the private sector would almost certainly lead to acute contradictions.

Execution, however, generally involves undertaking a process of 'development' with economic ends in view. Usually, although often not in the case of agriculture, property rights can be assigned to the embodied knowledge that results from 'development'. It follows that those who are to benefit (private sector organisations) should be responsible for the necessary investment. Again, the requirements of the market become progressively more relevant as the innovation approaches its ultimate commercial form so that those who understand the detailed operations of the market in question are permitted increasing cognitive authority as this point is approached. The implication is that near-market work is best performed within the productive organisations that pay for it, and will commercialise the resulting innovation, since these enterprises are best placed to know how to develop the product to meet the requirements of the market. An additional feature of near-market work is its interdisciplinary character. The nearer the work is to the stage of innovation (and so the further away from the discipline-based basic research stage) the more it needs to be conducted in an interdisciplinary fashion to respond to the complex demands of the market.

An important corollary of this view is that 'up-stream' research should be publicly funded and should be performed in institutions that on the whole are not subject to market forces. 'Near-market' development work, however, is best carried out within the productive sector where its performance may more easily be influenced by the needs of the market. More generally, the implication is that the different 'stages' may be housed in different types of institution and may be treated separately from an administrative standpoint.

Although these ideas appear to have been developed in the context of industrial development, they have had a noticeable influence upon policies intended to foster innovations that would facilitate agricultural development. The *Second Review of the CGIAR* [CGIAR, 1981] thus distinguished four types of research activity. *Basic research* is designed to generate new understanding; *Strategic research* is aimed at solving specific research problems; *Applied research* is intended to generate new technology; *Adaptive research* is designed to adjust existing technology to the specific needs of a particular set of conditions. More fundamentally, Hall and Clark [1994] argue that "in the early post-war period the

centralised research laboratory was seen to be the ultimate source of better technological practices on the land. Based on the success of the land grant universities in the United States ... there was a predisposition to place a great deal of faith in 'organised science' ... Moreover there was also a widespread recognition that reliance on market forces to allocate research resources would certainly lead to underinvestment on the part of poor farmers."

Some Problems with the Linear model

The previous section outlined an influential model of the process that leads to innovation. This model presents this process in terms of a number of hierarchically linked activities that span the spectrum between knowledge generation and knowledge use. Under this view there is a strict division of institutional labour between each activity. Different resource allocation criteria are used for different stages, each of which may be administered separately. Despite the differences in the nature of each stage, and the administrative and institutional barriers that may separate them, it is believed that knowledge flows in a smooth and unambiguous fashion from each stage to the next.

A considerable body of empirical evidence is now available to suggest that this model simply does not work. On the one hand, this evidence includes examples of innovative activity that are not as organised as the model would lead one to expect. Other pieces of evidence are cases where the innovative performance of institutions organised in harmony with the dictates of the linear model is apparently worse than could reasonably be expected. More fundamentally, recent developments in the theory of communication suggest that the smooth and unambiguous knowledge flows between stages that the model postulates are inherently implausible.

Clark [1994] presents two examples of attempts to separate the administration of 'basic' and 'applied' research that proved problematic because these supposedly distinct 'stages' were in fact virtually indistinguishable. The first followed the Rothschild Report (1971) which recommended separating the funding of 'basic' research from that having practical uses. For the latter, the research needs of government departments were to be determined by means of a "customer-contractor" principle. Research funding to meet these needs was to be alienated to the relevant department, to enable it to purchase the research that it

required. However, it was not easy to separate 'basic' and 'applied' research. "A more recent example is the privatisation of the 'applied research' parts of the Plant Breeding Research Institute (PBRI) at Cambridge. Webster [1989] shows how it proved impossible to come to a scientific judgement about what parts of the organisation were 'basic' and what parts were 'applied', and that the final decision in the end was made by a merchant bank."

The same author then refers to the situation of publicly-funded scientific institutions in "many" developing countries, stating that these research establishments are not contributing significantly to economic development: their weak or non-existent links with local industry mean that the knowledge that they produce remains unused. This experience, he suggests, demonstrates that 'knowledge search' activities do not automatically (or necessarily) provide usable inputs to the 'knowledge use' sector. Support for this point comes from Massey *et al* [1994], who find that productive units located on 'science parks' adjoining university premises in the UK often experienced difficulty in obtaining research support from the host university. These authors found that such productive units sometimes thought that academic knowledge was too general for their needs, sometimes that it was too distant from current engineering practice to be relevant too them. However, Clark [1994 p9] goes on to outline a number of initiatives within Britain that sought to build institutions that would harness research in the service of economic production, including a number that impinged on the higher education sector "often concerned with the grey area between postgraduate training and (industrially relevant) research but also targetting research council funds in ways that would not have been tolerated at times when traditional modes of science funding were in vogue". The inference that must surely be drawn from this account is that the 'pipes' linking different innovative activities require conscious construction and maintenance.

A more fundamental question is whether knowledge may usefully be thought of as 'stuff' that can be extended through a pipe. Such a metaphor is, of course, consistent with the diffusion model described by Latour, in which people passively pass on ideas (facts and artefacts) as if they were objects, denying that they play any active part in re-creating or developing them. However, it is argued that conceptualising communication between people working at the different 'stages' in this way leads to certain rather bizarre

consequences. The following sub-section will seek to make explicit these ideas that, it is suggested, are implicit in the 'linear model'.

Metaphors of Communication

The style of communication implied by the above account of the 'linear model' may be described by means of three of the popular metaphors of communication discussed by Krippendorff [1993]; the Container, Conduit and Control metaphors.³ Krippendorff argues that the first two of these metaphors were derived from technologies and provide no place for human understanding. Thus, the Container metaphor suggests that communication consists of sending discrete messages that *contain* "something". It suggests an understanding of communication in which "messages, language, pictures, even signals [are seen as] *containers* for meanings, ideas or things that *preserve them* on their passage to a destination where they can be removed". One entailment of this metaphor "renders communication *contents as entities with objective qualities*". The containers undoubtedly have a physical existence, while "it would indeed be difficult to imagine that material containers could hold immaterial substances" so that thoughts "become thing-like entities as well". From this it follows that "as objective entities, contents must exist independently of human experiences". Further, since the contents of messages are seen as existing independently of human experiences, communication will be seen as *transportation*, while understanding, "which may happen only after a message is transported to its destination, takes place *by contact* ... After removing contents from their containers, no interpretation, no reasoning, no particular cognitive effort is required to comprehend them."

Most of these points also apply to the Conduit metaphor, which expresses a view of communication "as a flow of certain substances through complex networks". The container/content distinction reappears in the channel/fluid distinction. Although this metaphor shifts attention from transportation in units to continuous flows, it retains the belief that entities or substances are preserved in the process.

³Krippendorff's paper is a reflection upon the understanding of communication held by people who choose to employ these common metaphors. His exposition seeks to draw out the implicit beliefs that these people are likely to hold. He does not present his ideas as universally valid, nor even as being logically necessary consequences of the communication styles discussed: such claims to universal knowledge would contradict the constructivist position that he espouses.

The Control metaphor evokes a style of communication that is consistent with the “separation of conception from execution” implicit within the linear model. If it were indeed the case that only activities close to basic science had agency while subsequent development and production were passive, quasi-automatic activities, then one would expect the communication from basic science down the ‘pipeline’ towards production to be of this type. This metaphor describes communication as being a *causal phenomenon* and therefore as a means to achieve particular objectives. Such communication entails “fundamental *social asymmetries*. Causes and consequences are respectively embodied in *controllers* and *the controlled ...*” Controllers assume the privileged position of *knowledgeable agents* working to achieve their own goals, while the targets of communication become means to realising those goals. Implicit in this metaphor is a view of the latter people as “reactive to stimuli, as causally determined *mechanisms*.” Since the purpose of communication is now seen as changing the thoughts and behaviour of other people, its success may be evaluated by observing the behaviour of the targets, perhaps by receiving feedback messages to inform the controller of successes and failures.

It appears, then, that the linear model of innovation implicitly prescribes a style of communication in which messages containing *objectively fixed* meanings are passed from basic science down the ‘pipeline’ towards production. Since these meanings are seen as existing independently of human experiences, understanding them is an essentially *passive* activity. All that is required is to extract the meaning from the message that contains it: efforts at interpretation are not needed. Recipients of these messages are expected to respond to the (fixed) meanings contained therein by changing their thoughts and behaviour in a pre-determined manner. Such an account of the style of communication between the different ‘stages’ follows in a more explicit manner from the diffusion model outlined by Latour. Latour’s view, however, is that the account given by this model represents an exercise in collective self-deception. He presents his model of translation, in which thousands of human and non-human actors play a far more active role in shaping and sustaining facts and artefacts, as being a more realistic account of the process usually known as innovation.⁴

⁴Thus he writes: “the black box moves in space and becomes durable in time only through the actions of many people; if there is no one to take it up, it stops and falls apart however many people may have taken

This latter model is consistent with the view put forward by Clark [1994], that *the knowledge relevant to any particular operation is largely determined by those involved in undertaking the operation in question*. The implication is that users of knowledge, far from being passive and obedient recipients of unambiguous messages, must in fact *specify* the knowledge that they need in a conscious manner and either generate this knowledge from their own technological resources or *search* for it from an external source. In the latter case, external knowledge must first be *interpreted* and then *assimilated* into the firm's knowledge base before it can be utilised. As Massey *et al* [1994] point out; "Evidence from innovation studies suggests that enterprises need highly specific knowledge in order to solve their problems [Pavitt 1984]". Knowledge of this specific nature is unlikely to be available from any source outside the firm, so the firm will need to make *active* efforts to interpret such external knowledge and so to derive from it the specific knowledge that is required. The high costs of assimilating knowledge and technologies from outside an enterprise [*ibid*] give some indication of the effort required to achieve this.⁵

This view, in which those who *receive* knowledge play an active part in the process of communication, suggests that the style of communication between 'stages' is akin to that described by the fourth of Krippendorff's metaphors; that of Transmission. Here, messages are *enciphered* into a form (signal) that only authorised addressees could *decipher* and read. Thus, messages are intelligible to the human sources and destinations while signals are intermediate 'translations' of these messages into a different medium, serving to transport them until they are re-translated into a medium that is again accessible to human understanding. This, for Krippendorff, is "a radical departure from the container and conduit metaphors, that meanings reside in human understanding, not in the signals transmitted". He points out that the style of communication described by this metaphor places a greater cognitive burden upon the communicators involved, both as senders and as receivers. While the conduit metaphor suggests that the mere exposure to messages is a sufficient condition for their comprehension, the transmission metaphor highlights the need for communicators to have some model of the encoding and decoding process. Further,

it up for however long before. But the type, the number and the qualifications of the people in the chain will be modified ..." [Latour 1983: 137]

⁵An additional point is that quite specific capabilities are required to undertake each of the activities mentioned in this paragraph.

such decoding is often referred to as *interpretation*. “We say a text must be interpreted to be understood. Readers translate a text into their own conceptual system, employing *conventional rules* of interpretation, which amount to using a common code ...”

The implication of the above discussion is that the *value* of knowledge depends upon the capacity of the user to *interpret* it, to *assimilate* it with in-house knowledge resources and then to *apply* it to the task in hand. Such a view is consistent with that of Clark [1992], that “knowledge is not ‘stuff’ that can be extended through a pipe but on the contrary is rather like electric current — resonating across different contexts and taking on ‘value’ (economic and scientific) depending upon the capacity of any context to give such knowledge meaning”. This value, he later wrote [1994], “has the ‘non-linear’ property that it depends ultimately on the interplay between supplier and recipient”. This means that “it is quite possible for a newly discovered piece of fundamental knowledge to take on immediate economic value provided a context exists for the knowledge to fit into and provided there are organisational/institutional structures which permit the existence of the knowledge to be understood and adopted. It is this essentially *cooperative* characteristic of the knowledge promotion process which is so important for efficient innovation and change.”

The task of incorporating these insights concerning the nature of ‘useful’ knowledge and the way it is communicated into a more satisfactory theory of innovation remains incomplete. However, Dosi’s synthesis [1982] of Sahal’s theory of technological systems with the results of a number of empirical studies of technological learning represents a considerable advance in this direction. Essentially, he presents a picture of innovative ‘knowledge use’ as necessarily including an active engagement in ‘knowledge search’ activities, with the latter being guided both by the technological history of the knowledge-using enterprise and by the ‘technological paradigm’ within which it operates. The virtual absence of earlier conceptual literature suggesting these ideas lends this advance something of the character of a quantum leap.

Technological Paradigms and Technological Trajectories: a critical exegesis

Dosi [1982] defines a technological paradigm as a 'model' and 'pattern of solution' of "*selected* technological problems, based on *selected* principles derived from natural sciences and on *selected* material technologies". Such a paradigm will thus constitute a complete 'outlook'. It will define 'relevant' problems and will include a set of procedures and of specific knowledge related to their solution.

Nor is this all: technological paradigms have a strong 'exclusion effect' focussing the efforts and imagination of technologists in particular directions, while blinding them to other possibilities. A paradigm will specify a generic task and a material technology exploiting particular physical and chemical properties, while 'progress' will be defined in terms of particular technical and economic parameters.

As for the origins of such technological paradigms, Dosi begins by considering the sequence of events by which discoveries in pure science lead to developments in technology and innovations in the productive system.⁶ He treats scientific discovery as occurring exogenously, simply because the links between social forces and fundamental science are too complicated to be discussed within the scope of his paper.⁷ However, it seems clear that only *a selection* of those "pieces of theory, puzzles, possibilities of development" within science are actually 'passed on' to become technology. The point at issue concerns the nature of the selection mechanism which operates here. Dosi *hypothesises* that at each point in the continuum between fundamental research and industrial production, economic forces, social relations and institutional factors operate as *selection devices*, applying such criteria as feasibility, marketability and profitability. The cost-saving capability of a possible path of development is likely to be an important consideration, while a strong tendency to seek to substitute capital for labour will be found in those societies of which industrial conflict and a struggle over income distribution are structural features. In general, such patterns of industrial and social conflict are likely to operate as important criteria in the selection process which determines the new technological paradigm.

⁶Even this author appears to assume that causality must run in this direction!

⁷Such treatment is probably legitimate: Coombs and Kleinknecht [1983] found that the innovations that they described as "new technological devices" or "new technological materials" occurred randomly over time.

Given that the same fundamental scientific knowledge could in principle be associated with many possible technological paradigms, it should be stressed that these general *ex ante* criteria are not sufficient to determine which of the many possible technological paradigms will in fact result. Dosi argues that more specific variables will also operate: he lists some as; (i) the economic interests of the organisation performing the research, (ii) the 'technological history' of this organisation and its particular fields of expertise, (iii) wider political and institutional variables, such as the actions of public agencies or of the military.

An immediate corollary of this view of innovation, published as the fifth 'stylised fact' on innovation in Dosi [1990], is that technical change is a *cumulative activity*. Thus, he argues that (i) the technologies currently in use tend to define the direction of technical change, (ii) the nature of these technologies often determines the range within which products and processes can adjust to changing economic conditions, and (iii) the probability of an organisation making further technological advances is strongly conditioned by the technological level that it has already achieved. Part of this cumulative technical change is accounted for by the incremental processes of 'learning by doing' and 'learning by using'. Bell [1982] reviews a mass of empirical evidence on the outcomes of such *incremental technical change*, finding that it may achieve a number of objectives. He finds examples where the nature and sourcing of inputs to production changed; where the final *product* gradually changed as its specifications were adapted to meet the requirements of its market; and where productivity — not only of labour but of all the factors of production — showed sustained growth over substantial periods of time. This finding, that "people and organisations, primarily firms, can learn how to use/improve/produce things by the very process of doing them" was later presented as the fourth of Dosi's 'stylised facts'. He suggests that these outcomes result from 'informal' activities such as "solving production problems, meeting specific customers' requirements, overcoming various sorts of 'bottlenecks', etc" [*op cit* p223].

Dosi thus presents a model of the innovation process that integrates in a satisfying manner the macro- and micro-level factors involved. His model is consistent with the description of innovating organisations that emerged from the above discussion of the linear model and its limitations, but says little about the specific organisational forms that are likely either to

promote or to inhibit effective innovation. These issues are illuminated by the subsequent work of such authors as Rothwell [1992], Gibbons *et al* [1994] and Quinn *et al* [1996].

Organisation for Innovation

For Rothwell [1992], the linear 'technology-push' and 'need-pull' models of the innovation process were rendered incredible by (for example) the findings of Project SAPPHO [Rothwell *et al* 1974] and the evidence summarised by Mowery and Rosenberg [1978], which demonstrated the simultaneous importance of both marketing and technical factors in successful innovation. The process of innovation was now seen as one of coupling science, technology and the market. By the mid-1980s, this author still regarded innovation as a "logically sequential" process that could be divided into a series of "functionally distinct" stages, but he described these stages as "interactive and interdependent". His work of this period went on to describe the overall pattern of the innovation process in terms of "a complex net of communication paths ... linking together the various in-house functions". He stressed that these communication paths transcended the boundaries of the firm and thus served to link it "to the broader scientific and technological community and to the market-place" [Rothwell 1992, p222].

Rothwell went on to argue that the defining characteristic of recent (since the mid-1980s) models of innovation has been the shift away from considering it as being a predominantly sequential process. Instead, the various different activities are seen as proceeding simultaneously, with all relevant departments being involved in appraising and defining innovative projects right from the start. Integration between the departments or organisations in which these activities take place is therefore seen as being vital for effective innovation. These fourth generation models (as Rothwell terms them) emphasise the importance of both vertical collaboration (with suppliers and leading edge customers) and horizontal collaboration (joint ventures and strategic alliances) with external organisations, so that innovation is seen as deriving from a network of companies interacting in a variety of ways. He speculates that the practice of innovation will develop towards conformity with a systems integration and networking model that he terms the fifth generation innovation process. This 'fifth generation' model describes innovation as being a multi-organisational networking process as well as an integrated cross-functional process, and

stresses the role of a new electronic tool-kit, particularly in facilitating close strategic integration between collaborating organisations.

In practice, various methods may serve to integrate the various activities involved in innovation, but in all cases of successful innovation “the emphasis is on interdisciplinary teams with the maximum sharing of information across functions” [ibid p225]. In particular, major new product development may require a specially formed and fully integrated project team. Such a team, it is argued, will integrate all parts of the organisation relevant to the project by stimulating effective internal information flows. An essential prelude to the formation of a project team is identifying those people whose contributions to the project are likely to be important and gaining their commitment to it. These people need not be drawn from the same organisation: indeed, as inter-organisational collaboration in innovation becomes increasingly widespread, so do such teams become progressively more heterogeneous.

The concept of the project team is developed by Quinn et al [1996 p78] into what they term a spider’s web. They describe this as “a form of self-organising network that ... brings people together quickly to solve a particular problem and then disbands just as quickly once the job is done”. This form of organisation “can flexibly combine high specialization in many different disciplines with multiple geographic contact points and a sharp focus on a single problem”, and means that “individuals work with many different colleagues on a variety of projects over the course of a year”. These authors see a spider’s web as an appropriate response to problems that are so complex or poorly defined that they exceed the capabilities of any single practitioner, so that “no one person or organization may know exactly what their full dimensions are”.

The importance of working in such a manner is confirmed by Gibbons et al [1994], who observe that effective innovation requires new configurations of knowledge and skills. The same set of specialist technologies and skills may repeatedly be configured in different ways to meet the (changing) needs of (varying) users. Indeed, they argue that an organisation’s competence in configuring knowledge resources determines its ability to innovate. Since these knowledge resources — specialist skills, knowledge and differentiated technologies — are embodied in people, re-configuring them involves changing the composition of

problem-solving teams as requirements evolve. Thus, “people come together in temporary work teams or networks which dissolve when a problem is solved or redefined. Members may then reassemble in different groups involving different people, often in different loci, around different problems.” [*Ibid* p6]

It follows from the above analysis that an organisation’s capacity to innovate depends upon its ability to respond to problems by assembling relevant people, by building trans-disciplinary teams and by re-configuring them into new teams as the questions evolve. Of course, as Quinn *et al* [1996] point out, the manner in which team members communicate, and what it is that is voluntarily communicated, is at least as important as the knowledge to which they have access. A team, then, is much more than a group getting on well [Moss-Jones 1995], and the processes that lead to the formation of an effective team are not automatic. It should be clear that a high level of competence is required to manage all of these processes effectively. Nor can there be a single ‘formula’ or ‘best way’ to build and manage an effective trans-disciplinary team since, as Quinn *et al* [*op cit* p78] point out, “each spider’s web is unique in its purpose, patterns, and organizational power relationships”. This observation may place in a new context the remark that “innovation is essentially a ‘people process’ and simply attempting to substitute formal management techniques for managerial talent and entrepreneurial flair is not a viable option” [Rothwell *op cit* p224].

The capacity to build and manage effective trans-disciplinary teams is thus seen to be vital for any organisation engaged in innovation. In view of the importance of this capacity, it is valuable to consider the fundamental processes that have to be managed. Since spiders’ webs are formed to undertake tasks that transcend the usual disciplinary boundaries, their members will need to employ a metaperspective based on concepts or problems, rather than on disciplines, in order to think about the issues involved. Hursh *et al* [1983] discuss the construction of a metaperspective, asserting that this requires the study of “(a) major disciplinary assumptions; (b) major units (levels) of analysis; (c) preferred forms of experimentation, data collection and analysis; (d) rules of evidence for asserting facts; (e) relevance to the specific problem; and (f) definitions of relevant concepts”.

Brekelbaum [1985] extends the above analysis, arguing that the construction of a metaperspective is a process that draws upon the activities of researchers in relevant disciplines, the concepts that inform their work and the research methodologies that they employ, but then compares and synthesises all of these. She stresses that "metaperspectives are not acquired simply by accumulating information on a given subject. That information must be organised and processed from a new perspective, identifying areas of conflict and ambiguity and then resolving them." [*Ibid* p45] This continual process of re-examination is intended to highlight the salient concepts of each discipline, to clarify conflicts between the value systems of different disciplines, and thus to uncover new concepts and approaches. [Hursh *et al* 1983 p55] Reflecting on her own experience of this process, she testifies that "this broadening of perspectives proved to be an exhilarating process, one that stimulated the mind, pushing it to its very limits. It was, however, a disquieting one as well..."

Little is known about the organisational conditions that favour the formation of metaperspectives, nor about the managerial strategies that are most effective in catalysing their formation. However, it is clear that a sustained process of team learning is involved, and this itself requires a set of skills that need to be learned. Senge [1993] notes that team learning using a process of continual movement between practice and performance is common in sports and the performing arts but rare in organisations. Such team learning requires the group to pay attention to the processes in which they engage (including the way that they organise themselves and the way that they work within this framework) and continually to reflect upon what they are learning from these processes.

Perhaps the primary task to be undertaken is that of building trust between the various researchers involved, trust that is essential if they are to work together as a team. Achieving this requires conscious efforts, including a commitment to spend a reasonable amount of time together. Quinn *et al* [*op cit* p79] confirm that continuity of contact is important in forming an effective spider's web, as is "encouraging shared interests, common values, and mutually satisfying solutions". They point out that wider organisational considerations, such as the rules for evaluating the contributions of each individual and for distributing the rewards for collective achievements, may be important in determining the degree to which those involved trust each other.

Conclusion: the production of 'useful' knowledge

From the above review of current debates around the management of innovation, the following three points emerge as being of greatest importance for articulating the argument of this thesis.

The first of these is a suggestion that useful 'applied' knowledge is not usually derived from more fundamental knowledge but is generated in the context of application. According to Clark [1994], this is because systems in the real world are far too complicated for their behaviour to be predicted on the basis of (essentially reductionist) 'laws of nature'. He argues inductively, considering specific examples and then seeking to generalise from them. Thus, he considers the type of knowledge that is possessed by an engineer building a bridge, arguing that such useful knowledge is likely to be craft-based rather than 'scientific'. "For example, while it is known experimentally that Young's modulus for alloy steel in specific conditions has a certain value, the performance of alloy steel girders within the wider contextual structure of a bridge is a much more complex phenomenon. In practice the engineer/architect bases his knowledge on past experience regarding how structures embodying that particular material operate under similar sorts of conditions." Clark then generalises from this example: "as soon as we are observing a system that is complex ... we are in a world where predictability is to that extent compromised. Every bridge is a new bridge. Our knowledge of its exact properties is only ever likely to be partial ..."

The implication is that one can learn about the behaviour of a complicated system *only* by observing comparable systems, by experimenting with them, and then by deriving operational principles in an empirical fashion. However, this would place the observer in the god-like position of being able to observe the systems under consideration without altering them, and thus to acquire objective (albeit partial) knowledge of their behaviour. In fact, reflection on Clark's bridge-building example suggests that the "past experience" on which is based the engineer/architect's knowledge will probably be experience of designing and building bridges. That is to say, experience of participation in a *human activity system*, one interpretation of which is to build a bridge [Checkland, 1994], rather than experience of observing or manipulating an external system. The stress now lies upon the learning that is an integral part (perhaps one aspect, or one interpretation of a complex

holon) of participation in purposive activity.⁸ Abstracting 'knowledge' (perhaps a statement of what has been learned) is a separate activity, requiring subsequent reflection on the learning experience.

It follows from this that strategic, application-oriented research is unlikely to be of value if it is performed 'in a vacuum'. Instead, close links between researchers and practitioners are required to provide the research with an appropriate context. One way to achieve this is to engage in a combination of 'action-research' together with deeper reflection to derive the strategic principles underlying this experience.

Secondly, as Gibbons *et al* [1994] point out, research intended to produce useful knowledge has to incorporate options for the *implementation* of the solutions found, and these are bound to affect the interests of different people, many of whom have traditionally been seen as outside the scientific and technological system. This means that the research process must take into account the interests of these stakeholders to ensure that the eventual solutions will be acceptable to them. In practice, achieving this will involve continuous negotiation among stakeholders and researchers to find compromises between what the different stakeholders want, and what is technically feasible. Such negotiation is an essential part of the process of innovation.

A third point is provided by Gibbons *et al* [1994]'s observation that *effective innovation requires new configurations of knowledge (and skills)*. The same set of specialist technologies and skills may repeatedly be configured in different ways to meet the (changing) needs of (varying) users. Indeed, they argue that an organisation's competence in configuring knowledge resources determines its ability to innovate. Since these knowledge resources — specialist skills, knowledge and differentiated technologies — are embodied in people, re-configuring them involves changing the composition of problem-solving teams as requirements evolve while maintaining the shared understanding of the task addressed that distinguishes a team from a group of talented individuals.

⁸Appreciative systems theory, as outlined in Checkland [1994], provides an elegant description of this learning process, but it is not clear that this theory adds anything to the exposition in the text.

Taken together, these three characteristics of the effective pursuit of innovation define a professional practice which depends upon intensive *negotiations* between people with different cognitive backgrounds. Knowledge, both of customer requirements and of a range of relevant technological sub-fields, is of vital importance to the process of innovation. Since few if any single organisations will possess expertise in all relevant sub-fields, this model of innovatory practice is likely to be conducted by means of a multi-organisational networking process. This model thus converges with Rothwell's *fifth generation innovation process*, which was discussed in the preceding section.

While the above analysis *prescribes* how innovation may be pursued effectively, it says little about the changes necessary if an organisation predicated upon a different model of effective behaviour is to develop the capacity to undertake 'fifth generation' innovatory practice. This, then, is the question addressed by the remainder of this thesis.

Chapter 2 The CGIAR and International Agriculture: continuity and change

Introduction

This chapter will examine the impact on poverty of past technical change in agriculture in developing countries. The experience known as the 'Green Revolution' will be analysed, and it will be argued that (i) the benefits to the poor that resulted from this experience were more limited than could reasonably have been expected, (ii) this limited impact reflected the research objectives pursued, and methodologies used, by the investigators responsible for the development of this technology. These objectives and methodologies are themselves strongly conditioned by the institutional framework within which the technology was developed, a framework that itself embodies a particular theory of innovation. As the discussion of the first chapter should have made clear, this theory is itself becoming increasingly controversial. In effect, the task of the present chapter is to trace back the outcomes of the 'Green Revolution' to the institutional embodiment of this theory.

This chapter is therefore intended to elucidate the structure and function of the institutions that catalysed the 'Green Revolution': the network of International Agricultural Research Centres (IARCs). This network has a long history: the foundation of the first of the IARCs (the International Rice Research Institute, IRRI) in 1960 was itself the culmination of a set of processes that began in the early part of this century. Jennings [1988] argues that the core assumptions made in the course of this 'pre-history' have continued to be held, so that even relatively recent actions and events are explicable in terms of these assumptions. An immediate corollary of this view is that some knowledge of the past is needed to understand the present. The first section of this chapter therefore reviews briefly those aspects of this history that seem to be of greatest relevance to events in the present and the recent past. It is hoped that this review will inform the following section, which outlines the 'formal' organisation of the IARCs and highlights the pattern of relationships with their main stakeholders upon which this organisation is predicated.

Two distinct analytical devices are employed to inform this exposition. The first of these is the 'linear' model of innovation (as outlined in the preceding chapter), which appears to

match closely the design of these formal arrangements.⁹ The second such device, discussion of the market and non-market characteristics of the relationships between the IARCs and their stakeholders, may appear paradoxical. After all, "there has been a revolution in thinking about economic policy in the developing world". The old consensus, which included "government planning and control ... of all major investment decisions" has been replaced by "a remarkably wide and strong consensus in favour of market-based policies" [Ryrie 1997, pp440-441].¹⁰ Since market and non-market mechanisms have generally been presented as alternatives, it is interesting that the CGIAR allocates resources in a manner that combines aspects of both of these opposed methods.

This account of the institutional arrangements intended to promote technical change in developing country agriculture is followed by a discussion of their effectiveness in alleviating poverty. It is argued that the nature of these institutional arrangements acted to condition the research objectives pursued, and methodologies used, within them: these in turn are reflected in the characteristics of the technology that resulted. A number of observers have argued that these characteristics are not entirely appropriate for the circumstances of the poor people for whose benefit the technology had ostensibly been developed: the 'circumstances' considered have included the agro-ecological environments of the land farmed by many poor people; the characteristics of the factor and product markets in which poor farmers need to participate, and of the labour markets through which the landless and those with inadequate land-holdings must earn at least part of their livelihoods.

As the above list of 'circumstances' may suggest, the rural poor are composed of several analytically distinct groups. The 'Green Revolution' affected the various groups in different ways. Consumers with low non-agricultural incomes almost certainly benefited from the decline in real prices that resulted from increased food production. However, the new technology did not adequately address the needs of poor producers even within the regions

⁹ For the remainder of this thesis, the terms 'linear model' and 'pipeline model' will be used synonymously, and will always refer to the 'science-push' variant of the linear model..

¹⁰ The passage quoted was written by a former Permanent Secretary of Britain's Overseas Development Administration (ODA) and therefore gives some insight into the views of the development establishment. The case for using the market mechanism to make decisions of this nature is usually presented in terms of the (allegedly) greater efficiency of the private sector. For critical reviews of these arguments, see (for example) Yacob Haile-Mariam and Berhanu Mengistu [1988] and Hamilton [1989]. Two empirical accounts of the application of market mechanisms to the provision of public services are given by Lacey [1997] and Larson [1997].

where it was introduced, and completely failed to address the needs of Resource Poor Farmers (RPFs) in Low Resource Agriculture (LRA).

The subsequent discussion will concentrate upon the relationship between agricultural research and resource-poor farmers. It will argue that the CG System's persistent failure to develop technologies appropriate for low-resource agriculture reflects the limitations of the 'linear' model of innovation: progress within this 'positivist' paradigm appears to be unable to deliver technologies that resource-poor farmers can use. Some general features of low-resource agriculture will be described, in order to discuss the kinds of research strategy and practice that are likely to generate technologies applicable under these circumstances. It will then be argued that the changes in research practice that would enable the IARCs (and comparable institutes) to address the needs of resource-poor farmers are precisely the same as those required for an effective response to the degradation of the natural resource base. These changes, it will be argued, would also permit a more adequate response to the circumstances of poor producers in the areas where 'Green Revolution' technologies have been adopted. Adopting such research practices would, however, represent a departure from well-established definitions of 'good research practice'. Such changes in the manner in which research is undertaken, together with the organisational changes that are required for their implementation, are likely to face sustained resistance.

Now, however, donors are displaying increasing concern about poverty alleviation and environmental degradation. This concern, together with their (essentially political) need to be able to show their own constituents evidence of a dramatic breakthrough, has led them to demonstrate their dissatisfaction with the work of the IARCs by imposing funding constraints [Ravnborg 1992].¹¹ The financial difficulties that the CG System now faces are thus in part a result of the limitations of the 'pipeline' model. An effective response to these difficulties must therefore include a move away from the established research tradition and the development of effective technical solutions for the problems faced by low-resource agriculture.

¹¹As Jiggins [*pers comm* 1994] explained, donors need to demonstrate to their constituents that the research that they are supporting is continuing to result in yield increases. It is not clear, however, how such additional yield increases are to be achieved, since modern methods have already been applied to resource-rich agriculture. Indeed, Lipton with Longhurst [1989] suggest that the natural limits to the yield increases that may be obtained in this way have already been reached. This suggests that low-resource agriculture now offers the greatest scope for obtaining further increases in food production.

Foundations of International Agricultural Research

The Rockefeller Foundation and its approach to Agriculture

Both Jennings [1988] and Anderson *et al* [1991] describe how, in the first six decades of this century, the Rockefeller Foundation (RF) guided the formation of the paradigm that Jennings calls positivist agricultural science. In this, the Foundation was itself guided by its traditions, and by a set of guiding principles that had been derived from its experience: Anderson *et al* list these as: employing technology as the leading factor, managing scientific research, building on strength and working through governments. At the same time, the RF enjoyed close links to the US State Department and Foreign Policy establishment and therefore worked within the context of the objectives of US foreign policy. All of these themes were to be recapitulated in much of the history of the IARCs: the first two are of the greatest relevance to the present discussion.

From the earliest days of the Rockefeller Foundation, the trustees had decided “to restrict the foundation’s direct operations to specific areas such as public health, medicine and agriculture” [Nielson 1972, p54, quoted in *ibid*]. This decision reflected “a belief in the universal applicability of science and technology” [*ibid* p30], a belief that solutions to problems would take the form of new technology produced by research. This belief in turn led to attempts to define ‘problems’ in technological terms: “Foundation records refer frequently to ‘tractable’ problems, those which will yield to the application of science and technology.” [*ibid*] Part of the rationale for this technology-first approach was the belief that technology is “the locomotive of economic growth”, so that “new technology is the key leading factor in the process of desired social change”. [*ibid* p31] This meant that the application of such new technology would, it was believed, “head off the direct structural transformations advocated by the communists”. [*ibid* p30]

Jennings [1988] notes that this belief incorporates the assumption that “social problems could be solved by extending human control over physical [and other] production processes”. Thus in the agricultural sciences, landscapes were analysed in terms of their productive capacities: the ‘problem’ was defined in terms of the productivity of agricultural land and so increased production was seen as being the ‘solution’. As Anderson *et al* [1991] note, this way of thinking meant that new technology could be applied to the

problem of inadequate food production without reference to the less tractable problems of land reform and distribution of output. Jennings argues that the spread of this way of thinking about the natural world was in harmony with the interests of corporate capital.

However, the new knowledge required for this chain of events to occur could only be produced if the necessary research was paid for and given proper direction. Indeed, new institutions would probably be required to house this research. These necessary conditions defined a clear role for the RF, which was well placed to provide the support necessary to begin this desired process. Scientists had always played a prominent role within its programmes and management, while its record of founding institutions to provide technological solutions had established the idea of 'mission-oriented research'.¹² This experience had helped to develop a particular tradition of research management. For Warren Weaver, director of the RF's Division of Natural Sciences, the role of the manager within this tradition was "an executive role which did not imply detailed supervision". [Kohler 1976, p280, quoted in Anderson *et al*, *op cit*]

The RF's undoubted comparative advantage in research management and institution-building must surely have influenced the decision taken in the early 1950s to re-affirm its 'technology-first' approach. This decision followed the efforts of Dean Rusk, the Foundation's newly-appointed president, to guide it away from health and disease issues (which he believed could be better handled by governments) and instead to stress agriculture. A mission sent to Asia (particularly India) to evaluate the Foundation's potential role reported early in 1952 that:

We would suggest that there are two types of activity which make sense: first, activities which explicitly face up to the complex and interrelated problems of ignorance and tradition, and seek to attack these problems; and second, isolable technical problems which are so important that their solution would find acceptance and application even under present circumstances. [Harrar *et al* 1952, pp25-26, quoted in *ibid*]

The RF's decision to concentrate upon 'isolable technical problems' clearly lies within its tradition of employing technology as the leading factor. The choice of this approach to developing-country agriculture led directly to a research programme that sought to increase

¹²For example, the Rockefeller medical research institutes in New York that later became the Rockefeller University, and the RF-supported malaria research institute in Italy.

production through the provision of improved germplasm, with improvement being defined in terms of increased yield of grain per unit area.

In terms of the approach chosen by the Foundation, low yields were seen as an “isolable technical problem” amenable to investment and scientific research. In effect, according to Anderson *et al* [1991], the definition of the problem as ‘isolable’ and ‘technical’ meant that the key variable, yield per acre, seemed to be a dependent variable while new technology was the independent variable. It follows from this that a technical solution could be introduced into any socio-economic environment and be accepted there without requiring complementary changes in social institutions other than those required to deliver the technology. The invariant, universally-valid character of the solutions sought doubtless suggested the phrase ‘positivist agricultural science’ as a name for this research tradition.

The above definition of the ‘problem’ formed one of the core assumptions upon which the Rockefeller Foundation’s involvement with Mexican agriculture had been predicated. This experience is itself of considerable significance, since it served as a ‘dress rehearsal’ for the approach that was to be practised by the CG System. In particular, the problem definition used to direct this Mexican Agricultural Project (MAP) re-appeared in the form of the research agendas of the first IARCs.

The Mexican Agricultural Project

Jennings [1988, Chap 3] argues that MAP was initiated at a meeting that took place inside the Senate Office Building (Washington DC, USA) on 3 February 1941. Henry Wallace, the vice-president of the USA (and former US Secretary of Agriculture), met Raymond Fosdick, the president of the RF, and J Ferrell, an RF officer who had previously proposed working in Mexican agriculture to hasten Mexico’s economic development. Wallace stated that Mexico needed greater agricultural production and suggested that demonstrations of agricultural practices should be located in the densely-populated central plateau. He explained that the RF was regarded as apolitical and so had advantages over alternative vehicles, such as collaboration between the governments of Mexico and the USA. He also stated that the reason for his concern with Mexico’s low agricultural productivity was the

“possible danger” that this posed in the context of a high birth rate. He concluded the meeting by emphasising the importance of Mexico in the national defence of the USA.¹³

Jennings [1988] characterises MAP’s work as the application and articulation of the paradigm, outlined above, that he calls positivist agricultural science. He notes that throughout the life of this project the ‘problem’ was defined in terms of the productivity of agricultural land and so increased production was seen as being the ‘solution’. The decision to seek this solution by means of plant breeding and genetics — a decision that set the course taken by International Agricultural research for subsequent decades — was made at a relatively late stage.

The work of MAP began in July 1941, when a team of three scientists was sent to survey agricultural conditions in Mexico. Their report stated that “most of the acute and immediate problems, in approximate order of importance, seem to be the improvement of soil management and tillage practices; the introduction, selection, or breeding of better-adapted, higher-yielding and higher quality crop varieties; more rational and effective control of plant diseases and insect pests ...”¹⁴ [quoted in Oasa 1981, p115]. The original recommendation of the survey commission was thus to improve the agronomic aspects of Mexican agriculture, giving priority to the improvement of soil management and tillage practices. However, it was noted that throughout the previous three years (1939-41) stem rust disease had caused extensive damage to areas where wheat had been most productive, leading to reductions in the area planted to wheat. Harrar, MAP’s leader¹⁵, argued from this that farmers would not be willing to invest in soil improvement measures unless stem rust could be controlled, concluding “that the fight against stem rust had to be won before the fight against poor soils could be won, but that both fights must be won before the campaign for enough bread could be won”¹⁶ [*ibid*]. Since plant breeding and genetics

¹³Jennings gives his source for this account as JA Ferrell, memorandum of conference with Vice President Henry Wallace, Tarrytown: Rockefeller Foundation Archives, 10 February 1941.

¹⁴Oasa gives his source for this quotation as EC Stakman, R Bradfield, PC Mangelsdorf, *Campaigns against Hunger*, Cambridge, Mass; The Belknap Press of Harvard University, 1967, pp32-33. These three authors comprised the RF’s original Survey Commission that visited Mexico in 1941.

¹⁵MAP was led by J George Harrar, a plant pathologist from Cornell University who in 1961 was to become president of the Rockefeller Foundation.

¹⁶Oasa gives his source for this quotation as Stakman *et al*, *op cit*, pp77-79.

were seen as the means to overcome stem rust, this decision elevated them to the apex of the pyramid of disciplines.

This hierarchy of disciplines was carried over, firstly into the organisation of IRRI and then into that of the other International Agricultural Research Centres. Thus, Anderson *et al* [1991 pp73-74] note that "the classic cluster of agricultural sciences found at research stations in the United States was transferred to IRRI. ... Scientists in the classic cluster of disciplines had their own hierarchy, which placed breeding and genetic manipulation on top. Within the cluster plant breeders had the greatest prestige, but could not work without the knowledge of experts in pathology, entomology and so on." The structure implied by this description, inter-disciplinary teams built around the requirements of varietal breeding, was widely replicated throughout the CG system.¹⁷

Another of the choices made at this stage but repeated many times within the CG system was to concentrate upon producing high-yielding crop varieties suitable for resource-rich agriculture. For Oasa [1981], this resulted from the application of the same rules of maximum results, high pay-off and demonstrability that had governed the Rockefeller Foundation's earlier overseas work. The greatest impact of this work was upon the fertile irrigated districts of Northwest Mexico, whose contribution to the national wheat harvest more than doubled (from 17 per cent to 38 per cent) between 1940 and 1950.¹⁸ However, the majority of Mexico's agricultural population lived in other regions, and relied upon maize rather than wheat. MAP's research on maize ignored the traditional practice of inter-cropping it with beans, instead developing high-yielding varieties suitable for resource-rich agriculture. This work therefore made a negligible contribution to Mexico's total maize output, which is mostly produced by resource poor farmers. [Jennings 1988]

¹⁷The associate director of IRRI, interviewed in 1978, confirmed that "perhaps there is a hierarchy in rice research ... breeders are at the top, because varieties come first" [Anderson *et al*, 1991, p107]. Indeed Pimbert [1991], working from within ICRISAT, presents this as the normal professional arrangement.

¹⁸The quality criteria against which MAP's breeders evaluated their work were of questionable relevance to developing countries such as Mexico. Jennings [1988] notes that the wheat varieties developed by MAP were selected for traits that made them suitable for mechanised cultivation and for specific applications in the food production system. For example, all promising strains were sent to the US Department of Agriculture for milling and baking quality tests in which their suitability for industrial processing was assessed by the same standards used for US domestic varieties: those strains that did not meet these demands were thus eliminated from the breeding programme. His source for this is given as the MAP Annual Report, 1958-59, pp63-68.

Chapter 2

This research agenda later faced a severe challenge, but the wealth and influence of the Rockefeller Foundation not only enabled MAP to withstand this but eventually served to convert Mexico's agricultural research system to pursuing the same agenda. In 1952, a new government came to power in Mexico. Stating that Mexico needed to expand maize production (because a shortfall in the supply of maize was anticipated), Flore Muñoz, the new minister for agriculture, placed MAP under his direct control. He used this new power to demand that MAP's Office of Special Studies "...drop almost anything else that they are doing and throw all of their personnel and their resources into the support of his extension program" [Warren Weaver's diary, 16 June 1953, Rockefeller Foundation Archives]. This stance was supported by the scientists attached to another research branch of the Ministry of Agriculture, the Agricultural Research Institute (IIA), whose report for 1955 included the following criticism of MAP's strategy:

Since irrigated corn accounts for only 5.3 per cent of the area sown annually, if yields are increased 50 per cent only in irrigated regions, total production will only increase 5 per cent. The best possibility for raising output is to be found in a modest increase in the yield per hectare in the non-irrigated regions which constitute 94.7 per cent of the total sown area.¹⁹

This stance implied a research strategy different from that pursued by MAP: instead of working to identify maximum increases in productivity, it required an examination of more extensive factors affecting harvests.

In responding to this challenge, the Rockefeller Foundation did not debate the relative merits of these different strategies but simply insisted that MAP should continue to enjoy the autonomy appropriate to a Program undertaking research based upon scientific rather than political grounds. Dean Rusk, the President of the Foundation, was asked by George Harrar and Warren Weaver to meet the President of Mexico and obtain "a strong reaffirmation of the autonomy of our activity in Mexico". They agreed that unless such a commitment were made "it would be the tragic fact that we would have no alternative but to diminish our activities or to withdraw" [Warren Weaver's diary, quoted by Jennings 1988]. In the event, Rusk succeeded in gaining President Cortinez's commitment to MAP's autonomy. This meeting marked a turning point in the relationship, after which the Foundation went on to establish its influence over Mexico's agricultural policies, eclipsing

¹⁹Jennings gives his source for this quotation as Cynthia Hewitt de Alcantara, *Modernising Mexican Agriculture*, Geneva: UNRISD, 1976, p39

the IIA. Just two years later, in 1954, Harrar noted that all of the key personnel in the extension service had undergone some training within the MAP. He speculated that they would therefore be loyal and would continue to collaborate with it in the development of their field programmes. Indeed, this was followed by moves within the Ministry to direct resources to the minority of farmers, those engaged in commercial agriculture. By 1956, the Ministry of Agriculture had allocated 96 per cent of its seed producing capacity to the production of hybrids. The paradigm of positivist agricultural science had been imposed upon Mexico's own agricultural research system.

As the following sections will make clear, a number of the features of this experience are helpful in understanding today's International Agricultural Research system. The Mexican Agricultural Project served to advance the objectives of US foreign policy: the US administration clearly saw it in these terms. It was implemented by an institution — the Rockefeller Foundation — that enjoyed close links with the US State Department and Foreign Policy establishment and therefore worked within the context of the objectives of US foreign policy. However, the Foundation was regarded as apolitical and later used this image of neutrality to claim for its activities in Mexico the autonomy appropriate to a Program undertaking research based upon scientific rather than political grounds. In fact, the Foundation's research activities were predicated upon the belief that new technology could resolve social problems. Such problems were therefore defined in technological terms, and efforts then concentrated upon the resultant "isolable technical problems". Thus, the 'problem' of Mexican agriculture was defined in terms of aggregate food production. This 'problem' was then addressed by a research programme that sought to increase output through the provision of improved germplasm, with improvement being defined in terms of increased yield of grain per unit area. Since these efforts were directed at the production of crop varieties with the genetic potential for high yields, rather than with the ability to tolerate environmental stresses, these varieties could more easily be used by better-endowed, resource-rich farmers. And since plant breeding and genetics had been chosen to be the instruments used in this quest for increased yields, these disciplines were placed at the zenith of a hierarchy. The involvement of experts in other disciplines in the project had to be justified on the basis of their contribution to these breeding efforts. This structure — an inter-disciplinary team built around the requirements of breeding new

varieties of a single commodity — was to become the basic research unit throughout the CG system.

The International Agricultural Research System

The CG System today

A wide range of actors operate in ways that may be interpreted as being directed towards enabling innovation in agriculture in developing countries. This section will examine a subset of these, consisting of the research Centres belonging to the Consultative Group on International Agricultural Research (CGIAR) together with their principal stakeholders. As Pretty and Chambers [1994, p195] point out, the CGIAR research centres enjoy considerable professional influence, so that “agricultural scientists worldwide see the Centres as embodying and setting the standards of professional excellence”. This account will outline the functional relationships that link the Centres with their stakeholders, and by virtue of which they may be thought of as a system.

The CGIAR describes itself as “an informal association of fifty-three public and private sector members that supports a network of sixteen international agricultural research centers” [CGIAR 1997]. This ‘informal association’ has “a loosely knit, decentralized structure and is funded by voluntary contributions”. The same ‘virtual page’ states that: “The mission of the CGIAR is to contribute, through its research, to promoting sustainable agriculture for food security in the developing countries. ... [Thus,] CGIAR centers conduct research programs in collaboration with a full range of partners in an emerging global agricultural research system.” Within this ‘emerging research system’ the CGIAR centres “specialize in strategic research in food and agriculture, forestry, agro-forestry, fisheries and food policy. They place equal emphasis on productivity research and natural resource management.”

Authors from a range of ideological perspectives concur that the International Agricultural Research Centre (IARC) represents a ‘notable’ or ‘remarkable’ institutional innovation.²⁰ Such Centres are internationally financed and staffed research institutes. Table 1 gives brief

²⁰ See, for example, Ruttan [1986] or Koppel and Oasa [1987].

information on all of the Centres currently supported by the CGIAR, including a brief description of the mandate of each Centre: the research focus assigned to it by the CGIAR.

The Centres enjoy considerable (but not absolute) independence: each Centre is an autonomous organisation, directly accountable only to its own Board of Governors. Each Board is independent, with members serving in their personal capacity, not as representatives of any institution or government, and is responsible for selecting the Director General, for approving the policies and budget of the Centre and for overseeing its programmes and management. Each IARC is therefore free to formulate its own goals and strategies independently: "The board, management and staff of each Center determine its own program directions; no external organisation has control" [Herdt 1984, p13]. This tradition of autonomy has a long history, as was noted in the previous section. Indeed, one of the founding principles of the CGIAR was that the research undertaken should be based upon scientific rather than political grounds [Ravnborg 1992].

From their foundation, they have been expected to produce technologies with a broad agro-ecological application. At least since the mid-1970s, this has meant producing so-called 'prototype technologies': generic knowledge that the national agricultural research systems (NARSs) of individual countries could use in their own more location-specific technology development activities. After this, the NARS pass the resulting applied knowledge through extension agencies and other service departments to the farmer, the ultimate beneficiary.

Centre	acronym	Year founded	Location	Main focus	Main activities
International Rice Research Institute	IRRI	1960	Philippines	Global rice improvement	rice
Centro Internacional de Mejoramiento de Maiz y Trigo	CIMMYT	1966	Mexico	Crop improvement	maize, wheat, barley, triticale
International Institute of Tropical Agriculture	IITA	1967	Nigeria	Crop improvement in humid and sub-humid tropics, land management, farming systems	maize, cassava, cowpea, plantain, soybean, rice, yam
Centro Internacional de Agricultura Tropical	CIAT	1967	Colombia	Crop improvement and improving agriculture in the lowland tropics of Latin America	rice, beans, cassava, pastures
Centro Internacional de la Papa	CIP	1971	Peru	Crop improvement	potato, sweet potato
West Africa Rice Development Association	WARDA	1971	Côte d'Ivoire	Rice improvement in West Africa	rice in swamps, upland and irrigated conditions
International Crops Research Institute for the Semi-Arid Tropics	ICRISAT	1972	India	Crop improvement and cropping systems	sorghum, millet, chickpea, pigeon-pea, groundnut
International Livestock Research Institute	ILRI	1974 (as ILCA and ILRAD)	Kenya	Research to enhance the role of livestock in sustainable agricultural production systems	biodiversity, production systems, animal health and feed resources, policy analysis
International Food Policy Research Institute	IFPRI	1975	USA	Strategies and policies to meet world food needs	policy analysis
International Plant Genetic Resources Institute	IPGRI	1976	Italy	Conserving gene pools of current and potential crops and forages	plant genetic resources
International Centre for Agricultural Research in the Dry Areas	ICARDA	1976	Syria	Improvement of farming systems for North Africa and West Asia	wheat, barley, chickpea, lentils, pasture legumes, small ruminants
International Centre for Living Aquatic Resources Management	ICLARM	1977	Philippines	Research pertaining to fisheries and aquaculture	fisheries
International Centre for Research in Agroforestry	ICRAF	1978	Kenya	Developing methods for evaluating agroforestry technologies	agroforestry systems
International Service for National Agricultural Research	ISNAR	1979	Nederland	Strengthening developing-country agricultural research systems	national research systems
International Irrigation Management Institute	IIMI	1984	Sri Lanka	Conduct research and communicate information on improved irrigation management	irrigation systems
Centre for International Forestry Research	CIFOR	1992	Indonesia	Strategic research and related activities	forestry, forest systems

Table 1: the CGIAR Research Centres, July 1997, based on Ravnborg [1992], ODI [1994], Greenland [1997] and CGIAR pages on the WorldWideWeb

The CG System and the linear model

Support for Research

There are a number of respects in which this institutional arrangement conforms to the linear model of innovation described in the first chapter. As discussed in the first chapter (see page 27), the linear model prescribes an institutional separation between 'knowledge search' and 'knowledge use' activities. 'Knowledge search' is seen as taking place within publicly funded organisations and as generating knowledge that may then be used by a market-driven productive sector of the economy. Such advocacy of public (or Royal) support for the pursuit of fundamental knowledge stands in a tradition that may be traced back to Bacon (see page 24). The support that the CG System enjoys from public funds thus corresponds to the prescriptions of the linear model.

Although strictly speaking the IARCs belong to neither the private nor public sectors, they are not subject to commercial pressures and the arrangements by which they receive financial support are akin to those prevailing in the public sector. Since 1971 they have been financed by the members of the CGIAR, which in effect is a loosely-organised association of donors, the majority of which are either national governments or public-sector multilateral agencies. The financial relations between donors and Centres are bilateral, and each donor is free to choose the level and composition of its contributions. Özgediz [1993], writing at the time when he served as Management Advisor at the CGIAR Secretariat, speculated that this freedom made the CGIAR an attractive option for donors. He described their relationship as resembling a simple market environment, in which donors acted as customers and Centres as contractors. Each Centre solicits funding for a portfolio of research projects, while each donor has certain objectives that may be met by investing in some of these projects. The reasons why particular projects do or do not get financed are thus essentially political, depending as they do upon the objectives of public bodies, together with the capacity of the IARC Directors-General to maintain fruitful relationships with these donors and to respond to their priorities [Ruttan 1986]. The constraints and opportunities faced by farmers only impinge upon this process to the extent to which they are reflected in donors' objectives.

Although these research projects are conducted by autonomous Centres, a mechanism operates to coordinate them into “a CGIAR systemwide portfolio of activities” directed towards broader objectives [Özgediz 1993 p224].²¹ These broader objectives reflect the ‘advice’ about “global priorities for international research as well as the funding each [C]entre would require from the donors if the priorities are to be observed” that is given to the CGIAR by its Technical Advisory Committee (TAC) [*ibid*]. This committee of “19 distinguished international experts from both developed and developing countries ... carries out reviews of the Centres, of overall priorities and strategies for the CG System as well as of topics of current interest” [Ravnborg 1992, p3]. It is “the primary outside body that periodically examines the programs of the Centers [and] ... advises on the research activities and directions of the Center staff” [Herdt 1984, p13]. The belief that it is possible for a central body to determine appropriate “global priorities for international research” is remarkable, given the range of locally-specific needs that research must ultimately address: this belief perhaps reflects a positivist view of the nature of agriculture. However Ruttan [1986, p315] did not appear to regard this belief as controversial when he wrote: “One of the great strengths of the CGIAR system is its planning and oversight role in welding the set of autonomous institutes into an international research system.”

In order to ensure that these “global priorities” are followed, the World Bank (IBRD) plays the role of a ‘balancing donor’, allocating its own donations to support whichever TAC-approved activities have not been funded by other donors. This helps to maintain programme continuity but is not an open-ended commitment: “Centres which continue to be relatively unsuccessful in fund-raising are put under some pressure to modify their bids/programmes appropriately” [Clark 1992, p12]. And the IBRD may (and does) reduce its support to Centres that devote a substantial proportion of their resources to activities other than those approved by TAC.²² However, the IARCs are free to accept ‘complementary’ funding — contracts to undertake a limited volume of ‘complementary’

²¹All the IARCs, taken together, are commonly referred to as the ‘CG System’. This usage is widely understood and therefore will be followed here, but without prejudice to the question whether it is legitimate to think of the totality of the IARCs as constituting a system.

²²In October 1995, CIAT was forced to refuse a donation of US\$2 million from the government of Norway when the IBRD threatened to reduce its contribution by a corresponding amount. At one level this was presented as providing the financial discipline necessary to encourage CIAT to undertake a painful episode of structural adjustment. However, well-informed interviewees suggested that this followed the failure of CIAT’s Director-General to take decisive action following severe criticisms of the Finance Director made by a team of external evaluators.

activities in addition to the TAC-approved 'core' programme. Such 'complementary' funding has become increasingly significant over the last decade.

Within the parameters set by this system of financing, the IARCs enjoy considerable independence. Each Centre is an autonomous organisation, free to formulate its own goals and strategies independently, but is expected to be sensitive to the wishes of its main stakeholders and to remain within the confines of its mandate [Özgediz 1993]. Clark [1992] has suggested that in practice the IARCs tend to be driven by traditional scientific values, although my own observations at CIAT do not entirely confirm this.

The Division of Scientific Labour

A second respect in which this arrangement conforms to the linear model is in the division of labour between the different actors. With their ready access to the segment of the global labour market concerned with elite scientists, the IARCs are able to draw upon the *basic* and *strategic* research of industrial countries and *apply* the results of this work to problems relevant to food production in developing countries [Ravnborg 1992]. Özgediz [1993 p218] thus sees the work of the IARCs as providing "a bridge between basic and strategic research institutions in industrialised countries and national research institutions in developing countries", a bridge that facilitates "the transfer of new agricultural technology from industrialized countries to developing country agricultural research institutions". While Özgediz wrote the paper quoted in a personal capacity, such 'linear thinking' is also found in a recent official document from the International Rice Research Institute (IRRI). Anderson *et al* [1991 p381] cite IRRI's 1990-94 *Work Plan*, commenting that it represents an attempt to position itself "between 'advanced institutions' and 'national programs', thus being a link between applied and basic research. Providing this link is called 'strategic research'."

It is important to note that this division of labour has changed considerably since the foundation of the first IARC. The mission of this first Centre was originally defined as the production of a widely applicable technical solution, so that only a subordinate role remained for national research systems. IRRI's first annual report (1962) thus states that it originally sought to produce "a variety of rice ... that will yield almost any time and

anywhere in the torrid zone” [quoted in *ibid* p64]. However, it became clear by the mid-1970s that “the productivity of the international agricultural research system was severely constrained by the limited capacity of many national systems and that the adaptation and dissemination of the knowledge and technology generated at the international institutes were dependent on the development of effective national systems” [Ruttan 1986, p316]. The reasons why this was the case are demonstrated by the example of IR8, the first high yielding rice variety that IRRI released. Despite its good performance in trials, its production impact was “modest” since, as IRRI’s *Long Range Planning Committee Report* later admitted (1979); “The miracle rice was not well suited to all environments, and equally high yielding varieties suited to poor environments were in demand ... The inability of the new technologies to fit the demands of the many different environments in which rice is grown was also a major factor.” [quoted in Anderson *et al* 1991, p69]

The revised strategy that followed this recognition acknowledged that it was not possible for a small number of global research centres to produce technologies suitable for use in a wide range of diverse agro-environments. For the Centres to serve effectively the wide range of environments within their mandates, they needed to work in partnership with the national programmes of the various countries served.²³ The task of the Centres now became Applied research leading to the production of ‘prototype technologies’ (or more generally research results) with a broad agro-ecological relevance, while it was now assumed that NARSs would be able and willing to use and further adapt these ‘prototype technologies’ [McCalla 1984, Ravnborg 1992]. These national research systems were more likely to possess the contextual knowledge necessary to use the outputs of the more strategic research performed by IARCs to craft technologies suitable for the agro-environments that they served.²⁴ Thus, the NARS were believed to possess a comparative advantage in responding to the needs of specific communities while the IARCs had a “general inability to deal with location-specific problems” [CIAT 1989, p15]. In effect, the new strategy meant that “[t]he agricultural research organisations of developing countries

²³In 1990 the CGIAR adopted a new Mission Statement that explicitly emphasised “partnership with national research systems” as the mode of operation for the IARCs [quoted in Ravnborg 1992, p42].

²⁴This was certainly the way that ILRAD, a CG Centre until its 1995 amalgamation with ILCA, analysed the situation, as reported in Clark [1992, p23].

are the primary client group toward which the technologies being generated by Center scientists are aimed" [Herdt 1984, p13].²⁵

Role of the National Programmes

The national programmes, for their part, have traditionally used the results of the Centres' research to develop 'packages' of technology and material inputs for the farmers in particular ecosystems ('recommendation domains'). The actual task of communicating these 'packages' and passing on the material inputs involved has been given to extension agents, each of whom is normally responsible for a certain geographical area. As argued in the first chapter (see page 36), implicit in this separation between (adaptive) research, communication and production is the belief that messages containing *objectively fixed* meanings may be transmitted from science to production. Since these meanings are seen as existing independently of human experiences, understanding them is an essentially *passive* activity. All that is required is to extract the meaning from the message that contains it: efforts at interpretation are not needed. Recipients of these messages are expected to respond to the (fixed) meanings contained therein by changing their thoughts and behaviour in a pre-determined manner. Thus, in words that have profoundly influenced extension practice [Ison, *pers. comm.*], Rogers [1962 p307] stated that: "The conclusion of the adoption process is either adoption or rejection of the idea."²⁶ This view does not admit the possibility that the idea may be transformed by the creativity of those who use it.

²⁵The implication of this strategy was stated by Horton [1986, p454], who distinguished 'production technology' (methods used by farmers and other food producers) from 'R & D technology — "the organizational strategies and methods used by research and extension programs in conducting their work". Thus, new R & D technology may have an 'institutional impact' upon "the capacity of research and extension programs to generate and disseminate new production technology". He then argued that because of "the great variability of farming systems and production problems, national and subnational programs have a comparative advantage in generating production technologies, whereas international programs have a comparative advantage in generating R & D technologies". From this he concludes that the "unique contribution of international programs to agricultural development is to supply R & D technology which improves [the] institutional performance" of the national programs. "Hence, the impact of international programs should be assessed primarily in institutional terms, not in terms of production increases at the farm level." [*ibid* p465] The extent to which the IARCs should work to develop the institutional capability of the NARS remains controversial: while many donors wish to see Centres becoming involved in administering direct assistance to national programmes, the view of TAC is that they should continue to be seen primarily as research institutes. [Ravnborg 1992]

²⁶ These words were advanced tentatively and hedged around with *caveats*, while this author's later work in communication theory advances a very different position.

The approach (wrongly?) associated with Rogers is apparent in the so-called 'Training and Visit (T & V) Extension', which "has been endorsed by the World Bank as the most desirable extension system" [Alemneh Dejene 1989 p1649]. Alemneh described the implementation of this system in Ethiopia, where extension agents attended monthly training sessions in a "specific recommendation" and then made regular visits to selected farmers (known as contact farmers). During these visits the "most suitable" practice is communicated to the contact farmers, each of whom in turn is responsible for explaining it "to about 10 follower farmers in his neighborhood" [*ibid* p1656]. Although Alemneh found that, for good reasons, farmers were unwilling to adopt some of these recommendations, there was no mechanism for correcting the definition of the "most suitable" practice. The T & V Extension thus assumes that the recommendations that it transmits are fixed, and do not require adaptation to local conditions. Alemneh concluded that this approach could be effective in serving fertile areas with adequate rainfall and good access to research, but that it had little to offer to other kinds of area.

Accountability for Agricultural Transformation

The national programmes (NARS), rather than the IARCs, are in most cases the immediate agents of agrarian change. Koppel and Oasa [1987] note that this has enabled the Centres to avoid accepting responsibility for such change (which was sometimes accompanied by disruptive social consequences) and so to maintain their image of benevolent neutrality.²⁷ While believers in the 'linear model' are unlikely to hold the NARS responsible for 'merely' applying the results of IARC research, other observers might be surprised at the absence of mechanisms that would enable national research systems — "the primary client group" of the Centres — to hold the IARCs to account.²⁸ Nor does this arrangement incorporate accountability to farmers: no mechanism exists for farmer problems to be communicated directly to IARC researchers [Clark 1994]. The 'linear model', as embodied in these arrangements, thus shields the IARCs from accountability to either their primary or secondary clients. However, the same way of thinking has also led to donors holding the Centres

²⁷The view of these authors is that, at least in the Philippines (and by implication elsewhere), the IARCs and NARS collaborated in active pursuit of the same essentially political agenda for social change.

²⁸This statement requires a little qualification since there are several ways in which NARS, working through their own governments, can influence donor decisions to release funds to IARCs. It should also be remembered that the CGIAR includes ten non-donor representatives of developing countries, and that a number of developing country governments are themselves donors and so participate fully in CGIAR discussions.

responsible for limited impacts of their work, even in contexts where weak NARS have been unable to communicate effectively with farmers.

The CG System, then, exemplifies the approach to research and technology development that is enshrined in the 'pipeline' model. This approach is particularly evident in the arrangements for supporting the activities of the IARCs and in the tasks that have been assigned to them by the division of scientific labour. Thus, while a quasi-market mechanism acts to make the IARCs accountable to their donors, this mechanism is diluted by the World Bank's role of 'balancing donor', which is exercised in order to sustain the overall research programme agreed by TAC. The judgements made by scientific experts are thus highly influential in determining which pieces of research are supported. Again, the influence of the linear model is evident in the IARCs' mandate to conduct *strategic* research and thus to generate results that are applicable to a wide range of situations. This definition of their role inhibits the IARCs from engaging with the complex, poorly-defined problems of fitting technology to the specific circumstances of particular users. Instead, their research has focussed upon the context-free problem of producing high-yielding crop varieties and thus has tended to lie within the positivist paradigm. The results of this approach to innovation will be considered in the next section.

Poverty and past technical change: the 'Green Revolution'

This section examines the impact on poverty of past technical change in agriculture in developing countries. The experience known as the 'Green Revolution' is analysed, and it is argued that (i) the benefits to the poor that resulted from this experience were more limited than could reasonably have been expected, (ii) this limited impact reflected the research objectives pursued, and methodologies used, by the investigators responsible for the development of this technology. These objectives and methodologies are themselves strongly conditioned by the institutional framework within which the technology was developed, a framework that itself embodies a particular theory of innovation, a theory that is becoming increasingly controversial.

The most widespread technical change experienced by agriculture in the developing world, the 'Green Revolution', occurred over a thirty-year period around the middle of this

century. Fears that population growth was about to outpace growth in food output within many developing countries led to the establishment of a new system of international agricultural research institutes (the IARCs), originally an initiative of the Ford and Rockefeller Foundations but now operating under the oversight of the Consultative Group for International Agricultural Research (CGIAR). Plant breeders working within these institutes developed new, high-yielding varieties of maize, rice and other food crops grown in tropical and sub-tropical countries by adapting the technologies that had already transformed developed-country agriculture. Since concerns about population growth and total food supply had inspired this work, the main objectives pursued were **quantity** (as indicated by yield) and to a lesser extent **quality** (as indicated by marketability).²⁹ These objectives were pursued by applying two principles hitherto mostly confined to temperate crops: 'hybrid vigour' and dwarfing. The novel twist of these early efforts in wheat and rice was the quest for wide adaptability, insensitivity to the length of periods of daylight (so that these varieties could be used throughout the tropics) and a changed crop architecture to give high yields in response to intensive use of inputs [Anderson *et al* 1987, p133]. For most of this period, the main methodology used was *selection for superior yield in fertile environments* (where abundant resources are available to the plant).

The 'abundant resource' methodology

This approach has the advantage that the breeder's objectives are well-defined and has often been justified as offering the only economic methodology [Boyer, 1982]. While such efforts have produced modern varieties (MVs) with the genetic potential for extremely high yields, most plant environments are sub-optimal, causing stresses that depress yields to a fraction of the plants' genetic potential. The enormous differences between potential and actual yields have attracted relatively little research attention, with the result that potentially substantial gains in plant performance in unfavourable environments have been comparatively neglected. In many (but not all) regions, however, oil-based agricultural inputs and artificial water control may be used to modify the immediate environment of the plant and thus (to a greater or lesser extent) mitigate the effects of such stresses. The costs of such

²⁹These goals were stressed in IRRI's articles of incorporation on its foundation in 1959 [Anderson *et al* 1991]. More than two decades later, the Second Review of the CGIAR ([CGIAR, 1981], cited by Ravnborg [1992 p6]) explicitly stated that the goals of the CG System were "to increase the quantity and quality of food production in developing countries with regard to not only technical, but also ecological, economic and social factors".

intervention limit the gains possible from adopting MVs, especially for poorer people in less-developed countries, while in some areas — particularly in much of sub-Saharan Africa — it is simply not feasible [Griffin 1979].

As well as this variation in the quality of the plants' immediate environment, another important difference between the conditions under which MVs are developed and those under which production takes place is pointed out by Lipton and Longhurst [1989]. They note that breeders generally work with single crops, grown in pure line stands for single seasons. Historically, however, farmers in many regions (especially in Africa) have mixed crops in a field and grown several crops in a year: such practices are rational strategies to manage risk and to make optimum use of family labour. Intercropping may also partly compensate for lack of fertilisers, if one crop restores nutrients depleted by another.

The availability of modern crop varieties (MVVs), developed for pure line cultivation, led to a variety of responses from farmers more accustomed to intercropping. Some of these farmers (generally those operating relatively large farms, with access to the capital necessary to finance mechanisation) responded by changing their method of working, planting pure stands of single crops to aid mechanical cultivation. The scientific success achieved within the laboratory thus led to the re-shaping of much of the outside world to resemble the world within [Latour, 1987]. At the same time, many other farmers were able to integrate the new varieties into their existing systems. Since these latter farmers tended to be less wealthy than those who adopted 'modern' farming methods along with the MVVs, one might reasonably expect that research intended to benefit poorer farmers would take account of these differences between the conditions under which new varieties are selected, and under which they will be used. Such expectations have generally not been fulfilled: instead, "intercropping research in Africa is often considered a retrograde step", a perception that reflects the excessive influence of "[t]raditional western agricultural curricula [which] discount inter-cropping" [Haugerud and Collinson 1991 p4].

Boyer [1982] argued that feasible alternatives to the "abundant resource" methodology outlined above do exist, but produced bibliometric evidence that very little research into 'low-input' agriculture had actually been carried out, and highlighted the lack of funding available for such 'alternative' research. To explain this, he noted that for most of the

post-war period it had been widely assumed that the 'abundant resource' approach to crop improvement was the only one that gives an acceptable economic return. Other authors provide additional clues. Both Coulter [1979] and Plucknett and Smith [1982] observe that breeding crops for adverse environments is more difficult than for fertile soils, so that progress is likely to be slow. Since the probability of success is perceived as being low, the researchers assigned to such tasks tend to be less well-trained and motivated than those who work on more tractable problems — to which scarce resources are more likely to be assigned [Brady, 1979].

The biological component of agricultural technology — along with the research system in which it is produced — thus conforms to Dosi's [1982] model of a 'technological paradigm'. The assumptions upon which such research is based, together with the behaviour of funding institutions and the structure of the scientific reward system, have all combined to encourage progress along the 'abundant resource' trajectory and to exclude other possibilities.

While this account masks considerable local and temporal variation, the fact that it is possible to outline in a few paragraphs the objectives and methodologies used within the entire CGIAR system is itself remarkable.³⁰ Indeed, this highlights the stability and uniformity of the 'research programme' pursued by a system of nearly twenty research institutes mandated to support agricultural development throughout the tropics over a thirty-year period. This stability and uniformity contrasts with the diverse and dynamic character of the agro-environments served, and is only possible because (as mentioned above) agro-chemicals and artificial water control are used to impose uniformity upon the outside world, making conditions in the immediate environment of the plant resemble as closely as possible the 'ideal' conditions of the research station.

³⁰As Ravnborg [1992] points out, a number of fundamental changes were recommended in the 1985 review of the CG System conducted by the Technical Advisory Committee (TAC) of the CGIAR. The first of these changes related to the introduction of the concept 'sustainable' into the statement of the System's objectives. Secondly, the TAC Review argued that the focus of research should change from agro-ecologically favoured areas towards more marginal ones, primarily in sub-Saharan Africa. It warned that implementing such a shift would involve dealing with a higher degree of diversity (the report used the term complexity) in technologies to fit the intricate and highly variable agro-ecological conditions of these areas. Thirdly, the Review argued that the emphasis of research in the CG System could change from applied towards strategic and basic research, as the strength of the NARs (assumed to be responsible for applied research) increased. But in other respects the Review argued for maintaining the *status quo*, both in the institutional and organisational character of the System and in the approach and content of the research.

Results of Change

Lipton and Longhurst [1989] present data showing that by the early 1980s the MVs developed in this way occupied about 50 per cent of the areas within LDCs planted to wheat, rice or maize, and estimate that perhaps 40 per cent of rural populations in LDCs cultivate mainly MVs. They note that in many areas with MVs, food production (per acre per season) doubled or tripled in 20-30 years and comment that: "History records no increase in food production that was remotely comparable in scale, speed, spread, and duration" [*ibid* p1]. Furthermore, many characteristics of the MVs seemed particularly favourable to the poor: by comparison with the varieties previously grown, they were labour-intensive, risk-reducing, and produced cheaper, coarser varieties of food staples. Yet the benefits to the poor were far more limited than might reasonably have been expected. Lipton and Longhurst repeat that without the MVs many millions of poor people now alive would have died in infancy, but cite compelling evidence that poor people's levels of consumption have remained stagnant in most LDCs.

These authors provide a two-stranded summary of the many attempts to resolve this apparent paradox — that when a bonanza for the poor could reasonably have been expected, the MVs merely provided a lifebelt. One strand notes that the MV technology did not adequately address the needs of poor people living within the regions where the MVs were introduced, and completely failed to address the needs of Resource Poor Farmers (RPFs) in Low Resource Agriculture (LRA). The consequent failure of MVs to diffuse into such agro-climates has resulted in greater regional inequality, particularly when farmers there have faced lower prices resulting from the increased output in MV-adopting areas. The second strand points to the highly differentiated social structure found in most of the regions where MVs were introduced.

The second strand of this explanation notes that the introduction of MVs, unlike earlier Agricultural Revolutions discussed, was not associated with a transformation of rural power structures: instead, the rural elites were able to use the MVs to strengthen their economic position. (Joffe and Greeley [1987] confirm this observation, noting that the distribution of benefits from MVs has corresponded to the distribution of assets prior to adoption, so that the structure of rural institutions — especially those concerning land rights — has been a major determinant of beneficiaries.) This is explained by reference to the

evolutionary manner in which MVs may be introduced: "An evolutionary technique — especially if used first by richer, less risk-averse farmers, with better access to information and inputs — tends, when introduced into an entrenched power-structure, to be used so as to benefit the powerful." [*Ibid* p401] Specific ways in which this happened include;

- (i) Richer farmers, with better access to credit and factor markets and greater tolerance of risk, were able to adopt MVs earlier and thus initially obtained innovators' rents,
- (ii) While MVs benefited the poor via higher levels of employment, this increase tends to fall off as better-off farmers seek labour-replacing ways to weed and thresh their crops,
- (iii) Food price restraint (resulting from MVs) benefits poor consumers, but this acts to restrain wages, so that in the longer term the bulk of such gains are captured by employers.

This outcome is contrasted with two earlier Agricultural Revolutions (ARs) — the Neolithic settlement and the medieval AR of northern Europe. These earlier ARs involved the diffusion of a package of innovations that were *non-separable, non-seriable* (piecemeal experimentation and partial adoption were not feasible) and *not single-unit* (an entire community had to adopt together). Under these circumstances, each member of the community benefits from giving up some surplus to support a system of authority able to force every other member to adopt the package of innovations. Such a complex of changes will thus tend to occur in association with the emergence of formal authority structures able to maintain the new techno-system: such structures will be valued as a 'public good' and so be able to secure widespread consent. Unlike these earlier ARs, the 'Green Revolution' technology can be introduced gradually, piecemeal, and individually. Thus the introduction of MVs does not require new forms of social organisation and so is unlikely to pose sharp challenges to the power structure within existing social systems: such power structures, in turn, are likely to direct MV benefits to the better-off people. However, the benefits of each AR (though less for MVs than for the earlier two) may be amplified by new kinds of public good, such as co-operative institutions to finance and manage common irrigation investments [Burke 1979 cited by Lipton and Longhurst 1989], and the provision of such public goods may entail changes in the local structure of power.

The technological needs of poor people within 'Green Revolution' areas

Part of the explanation given by Lipton and Longhurst [1989] for the limited poverty impact of the MV technology is that it failed to address the needs of poor people. The following two sections outline the arguments that these authors put forward to support this statement. However, these authors do not comment on the paradox that an apparently stable and homogenous 'research programme' exists to support a heterogeneous range of dynamic agricultural systems. Indeed, the fact that their criticisms and recommendations are couched in the form of 'once for all' revisions of the objectives to be pursued suggests that they share the belief that a 'static' research programme is an appropriate means to support these systems. Nor do they discuss in any detail the equally fundamental question as to why inadequate objectives were pursued, nor why the important research problems that they raise have not already been addressed. To answer these unasked questions, clearly, it is necessary to consider the information on the needs of clients (specifically, on the conditions under which production would take place using the new technologies) that is available to researchers. Institutional issues concerning the ease of communication between the 'domains' of science and of production are relevant here, as are the cognitive factors that determine the ability of researchers to comprehend the needs of their clients.

Research Objectives

These authors argue that the twin goals of quantity and quality pursued by plant breeders are inadequate objectives for efforts to reduce poverty. Both goals may be pursued by means that reduce demand for labour: breeding for herbicide tolerance to facilitate weed management may increase both the quantity and uniformity of crop, but at the cost of reducing employment for labourers. More generally, efforts to raise yields necessarily do so by increasing the productivity of scarce factors of production. But different people experience scarcities of different factors: rich people tend to be short of labour, while poorer people lack land and capital. The distribution of benefits from a new variety thus depends upon the relative intensity with which the different factors are used, and this must reflect the breeding strategy chosen.

The goal of quality, defined in terms of market acceptability, may also be unhelpful to the poor as food consumers, who may gain less from increases in quality than they lose from the

resulting increase in cost per calorie. Similarly, poor people may depend upon obtaining cheap broken grains, gleanage, straw for animal feed or thatching, or leafy parts of plants as vegetable supplements. Yet production of such plant parts may be reduced when yield increases, often defined in terms of high-grade whole cereal grain, are gained through improved partitioning, i.e. "enhancement of the yield of desired product at the expense of unwanted plant parts" [Simmonds, 1981].

Other goals have been given less emphasis by breeders than their importance to poor people would warrant. Lipton and Longhurst [1989] stress that rapid rural population growth is associated with increasing dependence among the poor on hired labour as a source of income to buy food and so requires that employment generation be given a higher priority by researchers: "*all other poverty impacts of MVs*", they state, "*will increasingly be subsidiary to their impact on incomes of hired labour*" (emphases in original). Poor farmers would also benefit from greater stability and sustainability of yield, as well as from better-understood cross-crop effects. But stable yield implies that the risks posed by adverse weather conditions and other hazards have been minimised, and this requires tolerance of a range of environmental conditions.

Further, as Greeley and Joffe [1987] note, "A common characteristic of most resource poor farmers is their need for risk-reducing innovations with a low input dependence...even where land is a relatively scarce factor. For this reason, stress tolerating innovations are often adopted more readily than those of an input-using or agronomic nature." Sustainable yield also requires that pest and disease resistance be based upon a number of distinct genes ('horizontal' resistance), possibly within distinct crop varieties: 'vertical' resistance (based upon a single gene) may break down within any given season, thus limiting stability, and will almost certainly break down eventually. Such a breakdown would contradict the goal of sustainability, and would cause most injury to poor farmers, since they have greatest difficulty in paying for chemicals to protect their crops from pests and diseases. Both varietal diversity and crop diversity may be important in securing plant populations against new pathogens. This argues for shifting some MV research towards neglected, less successful crops and towards mixed-cropping systems (which may be less susceptible to attack than monoculture and in any case assist farmers to manage such risks). Germplasm conservation may be important in this context.

The various general objectives outlined above are needed to select ways to extend past improvements in the efficiency of food plants. For example, while MVs make better use of plant nutrients than traditional varieties (TVs), researchers concerned to aid poor people should seek to reduce the capital-intensity of MV cultivation by finding ways to promote (i) more use of organic nutrient sources, (ii) 'substitution of labour for fertiliser' by improving the timing, placing or combining of nutrient sources. Such research should also consider the longer-term sustainability of recommended MV-fertiliser systems, while reviewing "the right balance of research among BT, other routes to nitrogen fixation, and nitrogen supplementation. Answers will vary by crop and agro-climate." However, this work would lie near to the margin of the 'abundant resources' paradigm and so scientists used to working within this paradigm may experience difficulty in undertaking such work. Evidence for this suggestion is provided by the following analysis of efforts to reduce dependence upon applied fertiliser, efforts that were marred by an insufficiently careful definition of the concept of food plant efficiency.

The twin objectives of high yields with no or low fertiliser are attractive, but (as Lipton and Longhurst [1989] warn) it is important to avoid creating MVs that promote soil exhaustion: the poor will suffer most if short-term gains prove unsustainable. Analysis of these twin objectives indicates that they may be achieved as a result of at least one of three distinct efficiency increases;

- enhanced nutrient conversion efficiency (increased output of biomass per unit of input resource). As was mentioned above, different people experience scarcities of different input resources, while the various resources are used differently by different crops or MVs, or even by the same crops in different places,
- better partitioning efficiency (a higher ratio of 'wanted' to 'unwanted' parts of the plant). Such changes affect water conversion, weed growth (since reduced leaf production diminishes the ability to shade out weeds) and fodder availability (since 'unwanted' plant parts may be important as animal feed) and so may raise questions as to the sustainability of the farming system,

- higher extractive efficiency (enhanced capacity to remove nutrients from the soil).
Gains in extractive efficiency may give short-term benefits but also increase the longer-term risk that soil nutrients will be exhausted. The risk is increased because the switch to such MVs provides short-term incentives to abandon some restorative practices (e.g. crop rotation) and to concentrate on growing intensively the same successful crop. Poorer farmers, who value immediate income more highly than future income, are especially likely to be tempted by such 'soil mining', as are insecure tenants who are unlikely to be farming the same land when its fertility declines. Researchers who develop such MVs should also find ways to keep them away from lands that are not rich in the nutrient(s) extracted.

Research planners should therefore distinguish between extra food yields resulting from increases in each of the above types of efficiency: of these, better nutrient conversion efficiency is always desirable, higher partitioning efficiency may sometimes be desirable (provided that the crop parts 'selected against' are not vital to the poorest), but enhanced extraction efficiency will only rarely be appropriate. These considerations should inform the following 'poor-friendly' research strategies;

- 1) researchers should explore the outcomes of various MV-fertiliser combinations (including mixed cropping) over *several* seasons, especially at low or zero fertiliser use,
- 2) before deciding on MV release, researchers should seek ways to encourage increased use of organic fertiliser and should review the long-term effects of such methods on different farming systems,
- 3) researchers should continue to work on new methods of nutrient enrichment that is already in progress (especially for nitrogen). Such methods range from slow-release fertilisers and enhancement of symbiotic systems with N-fixing organisms to improved BNF in the plants themselves. Some of these techniques — placing slow-release fertilisers in the root zone of individual plants, or preparation and application of N-fixing azolla — are labour-intensive and increase conversion efficiency,
- 4) since the ecological risks from MVs with high extraction efficiency will increase as their spread to more marginal areas continues, researchers should seek MVs with high conversion efficiencies but low extraction efficiencies that are suitable for use in mixed-cropping systems. Since mixed-cropping is labour-intensive and is found on small farms

these MVs would have major equity benefits and could share soils with crops that restored some of the nutrients used up by the MV.

In the light of this analysis, these authors express concern that “the choice of which MVs or recommendations to research or release appears to be little, if at all, guided by [distinctions between these different types of efficiency] at the low, or zero, levels of fertiliser use typical of very poor farmers and regions. Thus CIAT’s advocacy of ‘genetic manipulation [to improve a plant’s] capacity to ... use nutrients in the soil’ [CIAT 1984: 1-2] does not specify conversion efficiency, as opposed to extraction efficiency, as the goal; neither do its reported experiments usually appear to make the distinction. More worryingly, IITA’s advocacy of, and successful search for, cassava cultivars that outyield TVs unfertilised ... may involve grave long-term risks.” This discussion suggests that movement away from the established paradigm may only occur with considerable difficulty.

Technological Needs of non-Green Revolution Areas

Low Resource Agriculture

The research strategies outlined above could lead to important benefits for poor people in the areas already planted to MVs, but would have less impact on the many people who depend upon ‘remote’ agro-climates or crops for which no suitable MVs are available. For Greeley and Joffe [1987], such areas are characterised by “poorly developed infrastructure, little effective demand for or access to purchased inputs, absence of reliable and developed water supplies, and highly heterogeneous agro-climates. These areas include most of sub-Saharan Africa, remote areas of Asia and Latin America, many upland areas, and humid forested areas everywhere.” In addition, Chambers *et al* [1990, p xviii] note that these areas are often “undulating and with fragile or problem soils” and provide the setting for a style of agriculture that is “complex in its farming systems, diverse in its environments, and risk-prone”. Greeley [1992] argues that agricultural research has failed to benefit farmers in such areas, a charge confirmed by Greeley and Joffe [1987], who observe that only 1 per cent of African grain fields are planted to MVs of wheat and rice, while research into the staple food crops of the continent — sorghum, millet, cassava, grain legumes and others — has been seriously underfunded. For Chambers *et al* [1990] this failure can largely be explained by the inappropriate objectives that have been set: research has simply failed to

address the needs of RPFs, as opposed to those of 'green revolution' farmers in the better-endowed regions of LDCs. This state of affairs cannot continue indefinitely, for a number of reasons.

Firstly, these 'remote' areas are in many cases functionally related to the areas of 'green revolution' agriculture, serving as sources of water, of labour, and of genetic variability for the latter. This means that the continued impoverishment and degradation of 'remote' areas could, if left unchecked, eventually eliminate the gains of the 'green revolution'. A second reason is the increasingly widespread conviction that this failure to address the needs of large numbers of poor people is morally indefensible. Evidence for the serious effects of this failure is provided by Lipton and Longhurst [1989], who believe that the weak impact of MVs in such circumstances endangers many poor people, particularly when they face lower prices resulting from the increased output in MV-adopting areas. This may explain the third reason, donor concern at the limited impact of CG research, specifically upon sub-Saharan Africa but more generally upon less favourable areas with high degrees of variability [Ravnborg 1992]. Indeed, the donors' dissatisfaction with this limited impact and with the CG system's limited engagement with the question of environmental sustainability is such that they have lost confidence in the Group's own arrangements for setting priorities. Thus, total donations have ceased to grow, while funds have been shifted away from 'core' finance (support of the research programme developed by TAC) to 'complementary' funding (support of specific projects that satisfy donors' own requirements). The IARCs cannot afford to ignore these signs of dissatisfaction from their donors, but it is not clear how they can respond.

As argued in the previous section, the established research strategy of the IARCs is to develop 'prototype technologies' that are applicable over wide areas (subject to minor location-specific adjustments). Indeed, Horton [1984] noted that the agronomic principle of *input interaction* — that the combined effect on yield of applying several inputs and improved practices jointly is greater than the sum of the effects of each applied alone — had led many development experts and policy-makers to conclude that these 'prototype technologies' should take the form of complete packages. Efforts have certainly been made to apply this strategy to low-resource agriculture: Rhoades [1990 p8] notes that several international centres "are devoted to the creation of totally new farming systems, an area

where they feel they have a comparative advantage, especially for ecologically marginal zones such as deserts or tropical forests”.

However, these areas of low-resource agriculture differ in important ways from the ‘Green revolution’ environments to which the established strategy has generally been applied. For Ravnborg [1992], the most obvious of these differences lies in the opportunities that they present for irrigation. The limited nature of these opportunities in turn limits the feasibility of manipulating agro-ecological conditions in these environments, which therefore continue to present researchers with a range of intricate and highly variable agro-ecological conditions. This means that research targeted upon them needs to develop technologies that may be applied under conditions that are *marginal* and very *diverse*, with considerable seasonal variation.

It is far from clear that the farming systems and packages that result from pursuing the established strategy would consistently raise yields and incomes across this wide range of agro-environments. The difficulties of delivering complete packages, including the necessary infrastructure and water control, to areas of LRA, are well known. Additional evidence that, even in principle, such an approach would not be feasible, is provided by Horton’s account of research within the Mantaro valley (Peru) conducted by the International Potato Centre (*Centro Internacional de la Papa*, or CIP), a member of the CG System. Researchers at CIP developed three complete packages, all of which were then tested and evaluated on a number of farms in each of the three agro-ecological zones of the valley. The results of these trials were “disappointing” [*ibid* p43]: not only because the average yield increases, by comparison with the farmers’ technology, were far less than had been expected (because the seed used by the farmers was of much higher quality than the scientists had believed), but — more fundamentally — because the experimental results varied widely from farm to farm. Even within a single agro-ecological zone, yields using farmers’ technology and yield increases using each of the three packages both varied markedly, reflecting variations in soil fertility and weather conditions within the zone, coupled with differences in farmers’ management practices. Such was the variation that no single package represented an economic optimum under the diverse conditions of the various farms used for trials, even though they all lay within a single agro-ecological zone of a

single valley. Given this experience within a single zone, the difficulties of developing a single package suitable for an entire region or country must surely prove insuperable.

Such diversity of agro-environments is reflected in the diversity of the farming systems found within them. As Hobbelink [1991] explains, the inhabitants of these regions use their detailed, location-specific knowledge of the production possibilities of their immediate environment in order to craft production systems that will meet a wide range of needs. The wide range of outputs desired from these systems in turn means that they include a wide variety of components, the diversity of which also serves to reduce the risk of complete crop failure [Haugerud and Collinson 1991]. Knowledge about the interactions between different components of the farming system informs this process, which unfolds over time in a manner influenced by events (such as the timing of rainfall) in the external environment [Richards 1990]. The agricultural technology that is employed is thus extremely complex “in terms of the range of necessary inputs, skills and elements of knowhow” [Clark and Clay 1987 p164].

This account of low-resource agriculture receives empirical confirmation from Haugerud and Collinson [1991], who report that African farmers (taken as representative of resource-poor farmers everywhere) pursue a range of equally-weighted objectives, themselves varying with farm size, family structure, gender, wealth and market opportunities. These authors list the main concerns of African farmers as yield stability, short maturation periods, suitability for intercropping, ease of storage and particular taste or cooking characteristics. Small farmers (in Africa), they write, have detailed knowledge of differences between cultivars and the use of these differences in cropping strategies, strategies that are based on using mixed stands of cultivars. They give several examples to illustrate how different varieties are grown for different end-uses, and how farmers use variation in such attributes as the length of the growth cycle, disease resistance and tolerance of moisture stress to manage both natural and market uncertainties.³¹ These examples indicate that farmers’

³¹ Further examples in the same work demonstrate that, especially where land is scarce and where rainfall patterns permit more than one crop in each year, the length of the growth cycle may be critically important to farmers. They are not willing to adopt a higher-yielding variety if its longer growth period means that they do not have time, after harvesting it, to plant a second crop on the same land in time for the rains. If land is scarce, adoption of a longer-maturing cultivar may mean an unaffordable delay in planting another essential crop in the same plot, or may require earlier planting or harvesting of a previous season’s crop on

decisions about the adoption of new cultivars can only be understood in terms of the diversification strategies that they follow.

Low resource agriculture, then, is characterised by *complex* farming systems. Such a system (which may comprise several farms when events on one farm affect its neighbours, and certainly includes a number of decision makers) may be regarded as pursuing multiple evenly-weighted objectives and thus exhibiting optimising rather than maximising behaviour. Each component contributes to the goals of the overall system; the role of each component is probably intelligible only to someone who has grasped the logic of the complete system. 'Improvements' in the performance of individual components (such as new crop varieties with greater quantity and quality of yield) that detract from the performance of the system as a whole are counter-productive, and unlikely to be accepted by farmers. This means, in particular, that research on single crops, conducted without reference to the other activities that compete for farmers' land, labour and cash resources, is unlikely to respond to such system-level requirements. Since the 'abundant resource' approach to plant breeding has tended to concentrate on the performance of pure line stands of single crops grown under unrealistically favourable conditions, it risks irrelevance to low-resource agriculture. The implication is that plant breeding, and agricultural research in general, can only be relevant to this kind of agriculture if it takes account of the strategies followed. At least some knowledge of the strategies in question is a prerequisite for satisfying this condition.

These ideas about technical change in low-resource agriculture were developed further by Clark and Clay [*op. cit.*]. Their argument draws upon recent evolutionary models of technical change in the industrial sector. They note that this work, which analyses technical change in terms of technological paradigms and trajectories (see Chapter 1 page 38), is quite explicitly dynamic in character. They suggest that these models may also be applicable to LRA "since subsistence farmers are also agents of economic transformation, operating under conditions of great uncertainty and, to some extent, in a competitive environment" [*ibid* p164].

the same land. It may compete for scarce labour at critical points in the production cycles of other crops, or may introduce a family cash constraint if delayed harvest prolongs a period of cash shortage.

Dosi's picture [1982] of innovative 'knowledge use' as necessarily including an active engagement in 'knowledge search' activities thus highlights the role of farmer innovation in adapting a technology to their production circumstances. Indeed, Biggs and Clay [1981 p322] cite a number of empirical accounts of how "farmers will innovate within the limits of their technical capacity" in order to solve "the problems of simultaneous adaptation of a technology to both the physical and socio-economic aspects of an environment". They argue, not only that such behaviour is an essential part of "the transfer of technology and agricultural innovation", but also that farmers "are obliged to innovate in order to maintain even an equilibrium with the physical environment" because of "the dynamic imparted by the interaction of natural selection and purposive human intervention" [*ibid* p323].³²

Clark and Clay [*op. cit.* p164] note, however, that the technologies employed by resource-poor farmers depend upon their immediate environments to a much greater extent than is usual in the industrial sector: "a farmer's 'technology' is systemic in relation to a physical environment ... [while] even slight changes in the physical environment can change production possibilities dramatically. Technology is thus non-replicable." This means that a farmer's technological trajectory relates to "a given geographical area where he and his peers produce similar crop types using a 'technology' whose components represent some tried and true admixture of traditional and modern elements".

The argument of this section has been that low-resource agriculture is too important for it to be ignored by research, but that 'Green Revolution' research strategies are not applicable to this kind of agriculture. Different kinds of research strategy are necessary if the complex problems that are important to resource-poor farmers are to be addressed. The complexity of such problems reflects the nature of the farming systems in question, which typically are composed of a number of diverse interrelated elements. If research and its outputs are to be relevant to this kind of agriculture, the principle of requisite variety (discussed in the first chapter) suggests that it needs to match the diversity contained within

³² "Natural selection occurs by the action of environmental stress on inherent variation caused by gene recombination and mutation. This process occurs not only in the plants of economic importance, but also in the other biological organisms such as competing plant types ('weeds'), pests and micro-biological organisms. The process of natural selection has ensured that from earliest neolithic times there has been continuous evolutionary change, and not merely adaptation to a specific environment. The farmer is not moving iteratively towards some optimal point, but is only able to stay in dynamic equilibrium with his environment by continuous innovation." [Biggs and Clay 1981 pp323-4]

the farming systems under consideration. And these farming systems are themselves very varied, reflecting the highly variable agro-ecological conditions under which low-resource agriculture is performed. The task of research, then, is the development of technological elements that will fit into a wide range of distinct systems. One group of researchers thus defined their role as being to "identify and improve strategic components of different types of ... production systems". Responsibility for combining these components into the multitude of different, location-specific production systems that will eventually emerge rests with farmers [CIAT 1994 p123]. Such elements (or components) should therefore be amenable to further modification, since it is unlikely that a single element could emerge from the laboratory (or research station) and be suitable for use within the many different systems to be served.³³

Research for Low-Resource Agriculture

The above analysis poses severe problems, both for researchers seeking to address the problems of low resource agriculture and for policy makers seeking to encourage such research. While it suggests that detailed knowledge of the 'target' farming systems is an indispensable pre-requisite for relevant research, such systems in Africa (and by implication in other areas of low-resource agriculture) "are little understood by researchers [while] the proportions of output and area accounted for by distinct systems are seldom known even roughly" [Lipton with Longhurst 1989 p353]. The research questions that are important for this kind of agriculture are likely to transcend the boundaries (based on discipline or on commodity) around which most research is organised. An additional difficulty facing policy makers is that this kind of research involves work on mixed cropping systems, on upland areas and on weeds. Such work is of low prestige and has in the past been less tightly organised conceptually, and also less successful, than work within the established paradigm [*ibid*]. Efforts to adopt such goals may therefore face resistance from within the research community. It is therefore important to examine the possible ways of organising research so that it becomes sensitive to the needs and priorities of those of its users who are engaged

³³This seems to be an argument for a decentralised research system: perhaps also for replacing the established model of extension and technology transfer with a network of agents responsible for performing adaptive 'action research' together with their clients and for referring problems that they are unable to solve back to the formal institutes. Such 'feedback loops' seem to be missing from the established model of research and extension, based as it is upon the 'linear' model of innovation.

in low-resource agriculture. Policy makers need to consider institutional mechanisms that encourage researchers to work in this way.³⁴

The most obvious model would appear to be provided by the capital goods industries of developed countries, at best characterised by close linkages between the users and producers of technology. However, one immediate difference between the two cases lies in the vast difference in the number of consumers per producer. While a capital goods firm developing a product for a small number of customers (perhaps only one) is likely to devote considerable effort to 'customising' the product to the requirements of each user, this is unlikely when a single research institute is working for a large number of farmers. Perhaps a closer analogy would be with the 'white goods' industries (in effect producers of domestic capital goods), so that the methods of marketing and market research employed by these industries may be partially applicable. In fact, companies in these industries do sometimes research their markets by interviewing individual consumers (whom they believe to be in some sense typical), and may use imaginative methods to discover the desires and reactions of their subject, using such methods as allowing the subject to try out prototypes at home or to examine 'mock-ups' of alternative designs of new products.

Such companies depend for their very survival upon supplying products that their customers choose to buy and so are highly accountable to the needs of their users. They are therefore subject to strong pressures to discover the (perceived) needs of their customers and to work to meet those needs. Publicly-funded research establishments are not constrained by these market mechanisms of accountability and so are more susceptible to diversion away from the needs of their clients. This has led to suggestions that their activities should be transferred to the private sector, especially since the introduction of intellectual property rights covering new plant varieties means that these varieties are no longer 'public goods'.

³⁴One possible mechanism, advocated by Lipton with Longhurst [1989], is the use of formal decision rules to take account of different types of information in an objective fashion. It will, however, be clear from the preceding discussion that the information necessary for such procedures will not normally be available. Thus Clark [1980a] argues that attempts to apply standard methods of project appraisal to allocate research resources are utterly unreal, since the necessary data on costs, expected benefits and probabilities of success cannot be quantified (and may well not be known). Despite this warning, Ravnborg [1993] notes that "the preparation of national research masterplans [in which research priorities have been set using 'objective' methods] is becoming a *sine qua non* for African governments if they wish to receive donor assistance for their agricultural research systems". Her study of the Tanzanian experience strongly suggests that such 'objective' methods merely served to entrench established priorities and to shield them from scrutiny and from justifiable criticism.

However, as Greeley [1992] points out, most research aimed at meeting the needs of RPFs is unlikely to be performed unless it is publicly funded, since RPFs are unlikely to offer profitable market opportunities for the private sector. The introduction of mechanisms to increase and maintain the relevance of publicly-funded research to RPFs remains a near-intractable problem for policy-makers: while the literature gives a number of examples of well-organised, politically-influential farmers able to hold public-sector agricultural research to account,³⁵ RPFs do not have these characteristics.

Both Clark [1980a, 1980b] and Biggs [1982] have approached this problem by developing criteria for 'socially rational' behaviour on the part of research institutes. Clark [1980a] suggests that donors could make funding conditional upon such behaviour, and lists six criteria for this purpose. These criteria include;

- good socio-economic communications: liaison with "the productive sector" to gain information on the needs of the economy and guide research selection. Two common forms that such liaison takes are (i) formal representation on boards of governors — but this is unlikely to give sufficiently detailed information for research planning — and (ii) using the institute's extension and liaison service, but such services must explicitly be tasked to help perform *ex ante* evaluations, and this is unusual.
- employment of socio-economic analysts — staff with relevant social science skills responsible for appraising all projects and making recommendations to the research selection committee. They should be familiar with the relevant socio-economic sector(s) of the economy, and should also collect economic statistics and measure the degree of technology transfer achieved.

Elsewhere [Clark 1980b] the same author suggests performing pre-project techno-economic appraisals, to evaluate both the economic relevance and the probability of success of each project.

³⁵For example Leonard [1977] discussing colonial planters, Gelb and Kislev [1982] on agriculture in Israel, and Biggs [1982] discussing the US Land Grant Colleges

Biggs [1982] produced another such checklist, consisting of the following elements;

- justifying research against national development goals, so that research funds are allocated to national priority problem areas,
- client group oriented research, so that each project or work programme will identify the specific socio-economic group of farmers (and part of the country) whose needs it addresses and so may be related to national development goals,
- specific problem-solving research, clearly directed at solving the problems of clients,
- rewards to scientists whose innovations are widely adopted,
- application of inter-disciplinary analysis, so that the applied natural scientists responsible for developing a new technology are made aware of socio-economic as well as technical issues and take these into account throughout the R&D process,
- integrated field and experiment station programmes, so that on-farm surveys, experiments and field trials are integrated into all research programmes,
- communication between scientists, both between institutions and within each establishment, so that results and technical information diffuse readily to all who can use them.

(This factor also appears in the checklist presented by Clark [1980a].)

Both of these checklists focus upon the innovation-pursuing behaviour of individual research institutes and would appear to be of greatest relevance to national agricultural research systems (Clark's work was produced as part of a study of the Nigerian NARS). Implicit in both, however, is an awareness that information from different sources is important in generating innovations. In particular, they explicitly acknowledge the importance of information provided by the productive sector, and by researchers in different disciplines. The suppliers of such information are likely to be based in a variety of institutions, all of which are thus seen to be contributing to the process of innovation. This view is consistent with that of Biggs [1990], who argued that innovations do indeed emerge from multiple sources.

Knowledge Networks

Inter-Organisational Networks

In practice, then, agricultural innovations emerge from multiple sources, with both strong and relatively weak links to the CGIAR system [Biggs 1990]. The division of labour

between such organisations is neither clear at any one point, nor fixed over time. This collaborative character of the innovation process raises a number of additional policy issues:

- strengthening different patterns of networking and information exchange between organisations (such as encouraging dialogue on research policy between institutions whose strengths lie in social and in biological research)
- enabling different organisations to appreciate the validity of each other's perspectives on the task(s) in hand, so that inter-organisational conflict can be managed and their activities coordinated [Kersten 1995]
- since these varied organisations are oriented to different client groups, allocating resources between them represents an implicit choice between different groups in society. Such allocative decisions inevitably affect inter-organisational power relations.

One "pattern of networking and information exchange" that might make research more sensitive to the needs and priorities of resource-poor farmers is collaboration between research institutes and NGOs, collaboration that includes a dialogue on research policy. Kaimowitz [1993], discussing the Latin American context, notes that NGOs are comparatively close to their clients, who typically include disadvantaged groups such as RPFs, while farmer participation in agricultural research and technology transfer is an explicit objective of most NGOs. However, the technical capacities of most NGOs are limited, so that they are unlikely to become centres of technical expertise. Indeed, Bentley [1994 p145] confirms that NGO staff and other people "who can live and work in remote villages ... often lack the technical agronomic knowledge to do formal scientific research". NGOs could therefore benefit from the technical strengths of the research institutes, and in turn could "serve as information brokers between scientists and farmers" [*ibid*]. Ideally, such collaboration could provide a mechanism for representing farmers' perceptions in the definition of the public research agenda. This suggestion will be considered in more detail in Chapter 4.

Another question raised by the above suggestion is whether NGOs could use their links with international networks to gain access to such a dialogue on research policy. After all, the

IARCs have become increasingly dependent upon relatively short-term funding agreements, and so have been forced to adapt their research programmes and working practices in response to donor pressures [Ruttan, 1986]. These donors in turn are essentially public organisations in developed countries and so may prove susceptible to lobbying from NGOs and pressure groups within the same countries but linked by networks with NGOs in recipient countries seeking to enter a policy dialogue.

An important *caveat* to this discussion is suggested by the empirical data presented in Chapter 5. This is the observation that NGOs are very varied, and may differ markedly in their perspectives, their objectives and in the specific client groups that they serve. It is unlikely, therefore, that an automatic consensus will exist among the various NGOs concerned with any given issue. The decision to collaborate with any particular NGO thus presupposes that a wide range of choices have already been made.

Farming Systems Research

The tradition known as Farming Systems Research (FSR) represents an influential approach to the question of conducting agricultural research in a 'socially rational' manner: for Kersten [1995 p30] its main contribution has been to provide "a 'market' orientation to agricultural research through a clearer focus on the potential clients of technology". This vast and diverse literature was summarised by Maxwell [1986a p66], who noted that it represented "a number of alternative paradigms ... [organised] around a common set of principles ... These common principles include the farmer-centered nature of research; the holistic nature of farming systems; the need for multidisciplinary analysis; the importance of on-farm work; and the iterative, continuous nature of agricultural research."

The principles of FSR have generally been operationalised as a five-step process. Maxwell [*ibid*] describes these steps in the following terms;

- (i) "*Classification* is concerned with the identification of homogeneous groups of farmers with similar natural and socio-economic characteristics." The remaining steps can then be performed for one or more of the client groups thus identified.
- (ii) "*Diagnosis* has to do with identifying the limiting factors and development opportunities of particular target farm types identified at the classification stage."

- (iii) The *generation of recommendations* is undertaken in order to remove some of the limiting factors and/or to exploit the development opportunities identified in the preceding stage. This is likely to involve experimentation, which may be conducted on the farm and/or at the research station.
- (iv) *Implementation* of the changes recommended.
- (v) *Evaluation* of the consequences of these changes, normally leading “to reappraisal and therefore to a reinitiation of the cycle”.

The influence of this approach is clearly discernible in CIP's work in the Mantaro valley, discussed above (see page 79). As Horton [1984] made clear, this project was based upon the employment of inter-disciplinary teams, combining social and biological scientists, to perform applied farm-level research. This proved to be an effective arrangement: the “holistic ecological framework and rapid, effective survey methods employed by the researchers were extremely useful throughout the research process” [*ibid* p58]. The value of this interdisciplinary manner of working was demonstrated by the method of diagnosing the farmers' problems, leading to a common definition incorporating both social and technological perspectives. It is important, Horton observed, that both social and biological researchers be involved in this: unaided, social scientists are unlikely to understand the technology of production sufficiently to obtain sufficiently specific and precise information on key technical variables for pinpointing production problems.

The experience of this project does, however, raise some doubt about the validity of the FSR methodology. This is because of the wide variation that was observed between different farms, even within the same ecological zone of the same valley. Such variation suggests that in areas of low-resource agriculture it may not be possible to identify “homogeneous groups of farmers with similar natural and socio-economic characteristics”. If the initial *classification* step cannot be performed, then it will not be possible to define the client groups for whose benefit the remaining steps are to be undertaken. This experience is consistent with that of CIAT's Farming Systems Programme (discussed in Chapter 3 below), which was eventually closed down because of its inability to resolve this difficulty.

Indeed, the researchers involved in the Mantaro valley project found that not only the benefits but also the difficulties of interdisciplinary on-farm research were far greater than

they had anticipated. Difficulties arose from the barriers between different disciplines, since specialisation limits both the motivation and the ability of scientists to communicate across disciplinary boundaries. And Horton also noted that the system of professional incentives may inhibit interdisciplinary teamwork: attainment of 'high scientific standards' usually requires the use of sophisticated procedures that are often unsuitable for use at farm level, so that scientific rigour may result in a loss of relevance to the needs of farmers. He found that pressures from university thesis committees and from the editors of journals tended to intensify such problems and so reduce relevance.

The above account of the problems that resulted from CIP's system of professional incentives and its disciplinary structure suggests that institutional change at the level of the research station may be necessary to implement FSR effectively. This suggestion is consistent with the experience of a national research station, organised along disciplinary lines as a series of autonomous specialist departments, which introduced a new farming systems project without changing other parts of its structure [Maxwell 1986b]. The new project experienced considerable difficulties, partly because "[l]ines of communication between the head of the [FSR] project and the leaders of the disciplinary teams were not always clear and there were several disagreements about control over research programmes in the project area". Indeed, "it became apparent that the [FSR] project operated as an isolated unit within the institution" [*ibid* p27]. The head of this project "had no control over the research carried out by the members of the other [departments] and therefore had very little control over the physical operations of the [FSR] project" [*ibid* p31].

Farrington and Mathema [1991] outline the ways in which a Bolivian national research station sought to make its internal structure more compatible with the systems approach. Until 1986 it had been structured along conventional commodity lines. However, as the validity of the systems approach gained increasing acceptance, it gradually became clear that a commodity-based structure was inadequate to house research that would consider important systems interactions. Structural alterations were therefore required: a newly-appointed sub-Director was responsible for proposing these.

After lengthy internal discussion, a structure was introduced in which two broad agro-ecological zones were defined, multidisciplinary teams being assigned to each. After

reviewing existing knowledge of the farming systems for each zone, research staff were allocated to them according to discipline and experience. This move towards a problem-oriented and systems-focused research strategy was accelerated by a budget cut in 1987: those programmes incompatible with this approach were the first to be threatened with cuts.

The fifth chapter of this thesis will discuss an attempt to introduce inter-disciplinary research that was not accompanied by complementary institutional reforms, and will consider the consequences of this arrangement.

Farmer Participatory Research

As argued above (see page 81), researchers seeking to address the problems of low resource agriculture need to base their work upon a detailed understanding of the 'target' farming systems, while this kind of information is not generally available. For this reason it was at one time common for FSR projects and other technology development programmes oriented to small farmers to begin "with elaborate surveys designed to set objectives for the on-farm experiments and to formulate research agendas" [Ashby *et al* 1990 p115].

However, it was found that the "complexity of small-farmers' decision-making is such that it can take a team of specially trained researchers weeks of fieldwork to achieve this, using *sondeo* teams, informal surveys, rapid appraisals, key informant surveys, etc" [*ibid*]. In effect, acquiring the detailed background knowledge necessary for such technology development programmes proved prohibitively expensive, particularly since the systems investigated varied widely with the agro-environments in which they were embedded. And this (expensive) task would probably need to be repeated in order to adapt any technology produced for use in the different systems found in subtly distinct agro-environments.

Farmer participatory research, in which farmers take an active part in the research process, has been presented as offering a way forward from this impasse [R Knapp, J Ashby; *pers comms*: Ashby *et al* 1990]. Indeed, Greeley [1992], following Chambers *et al* [1990], argues that greater farmer participation in setting research objectives and evaluating outcomes is a precondition for addressing the needs of resource-poor farmers. This approach serves to link the 'domains' of research and of production: it may be compared with conventional market research approaches to product development, including those

practised by 'white goods' manufacturers. Essentially, this approach represents an acknowledgement that the researcher does not understand the systems within which the resulting technology will be used (systems that will also be affected by the operation of this technology) and is a method of using the implicit but less incomplete knowledge of these systems held by those who work within them.

However, working in this way requires that researchers form a partnership with farmers (and other local people), and there can be little doubt that a new professional practice is required to achieve this. Indeed, Greeley [1992 pp12-13] argues that greater farmer participation will involve "substantial reversals in conventional agricultural research practice. Thus ... there are constraints imposed by the institutional conditions under which agricultural research is conducted." An additional 'institutional' difficulty faced by IARC-based researchers is that work carried out in response to the needs of a particular project site will inevitably have a location-specific character, and so may be seen as the task of the relevant NARS rather than that of a CG Centre.³⁶

Professional Practice to serve Low Resource Agriculture

A number of commentators, most notably Chambers and Pretty [1994], have argued that a new professional practice is required if researchers are to deliver technologies that are relevant to the needs of RPFs. The view of these authors is that research intended to facilitate the achievement of growth and regeneration in complex, diverse and risk-prone areas can only be effective if it is founded upon the needs and views of farmers, and that complementary changes in professional behaviour, institutions and policies are required to achieve this. In particular, Chambers and Pretty believe that a new paradigm is required to address these issues. They distinguish three dimensions of this new paradigm;

New learning approaches and environments

"The central concept of the new paradigm is that it enshrines new ways of learning about the world. ... Professionals who are to work with local complexity, diversity and

³⁶Thus Horton [1984, p11] writes: "A common argument against farm-level research, especially at the International Agricultural Research Centres (IARCs), is that results are location specific and cannot be extrapolated to other areas. On the basis of this reasoning, on-farm research should be in the domain of national programs and the IARCs should limit their involvement to training and backstopping (preferably through special funding)."

uncertainty need to engage in sensitive learning about the particular conditions of rapid change.” [ibid p183]

New participatory approaches and methods

These authors seek to identify a set of common principles that underlie a range of experiences of participatory approaches [ibid p184]. Unfortunately, they provide a list of principles and do not explore ways in which these principles may be linked analytically. Their list includes the following descriptions;

- “the focus is on cumulative learning by all the participants”
- *Multiple perspectives* — seen as the explicit acceptance that different people “make different evaluations of situations” and therefore believe that different actions are an appropriate response. Further, “all views of activity or purpose are heavy with interpretation and prejudice” so that “there are multiple possible descriptions of any real-world activity”.

An immediate corollary of this second principle (although the authors give no evidence that they are aware of the logical link) is that

- “the complexity of the world will only be revealed through group inquiry”. They suggest that such groups may include researchers from different disciplines, together with local people “from different sectors”.
- *Facilitating experts and stakeholders* — these approaches are intended to transform existing activities in order “to bring about changes which people in the situation regard as improvements. The role of the ‘expert’ is best thought of as helping” these people to learn about their situation and so to achieve an outcome that they regard as desirable.
- *Leading to sustained action* — “the inquiry process [outlined in the preceding principle] leads to debate about change, and debate changes the perceptions of actors and their readiness to contemplate action. ... [This] analysis both defines changes which would bring about improvement and seeks to motivate people to take action to implement the defined changes.” If action is agreed, it will represent a compromise between conflicting views. Such action may include the building or strengthening of local institutions, thus increasing the capacity of people to implement change. (This last principle is substantial, and appears to be based on the ideas of Rölíng, although at no point do the authors acknowledge this debt.)

New institutional settings

After criticising the bureaucratic nature of “many agricultural institutions” (no evidence is given for this assertion!) Pretty and Chambers [p184] state that different institutional characteristics will be required to support the professional practice that they favour. They go on to synthesise the preceding discussion in their account of the new roles implied for agricultural development professionals, apparently based on the requirement that they “learn from and with farmers, and so serve diverse and complex conditions and farming systems”.

The New Professionalism

New professionals are characterised as being “either multidisciplinary or work[ing] closely with other disciplines”; as able to work with “the complexities of close dialogue with farmers and rural people” and as continually being “aware of the context of inquiry and development” [*ibid* p187]. A table [p186] presents seven characteristics of the new professionalism. While they are presented as if they were independent items on a shopping list, links may be discerned between the most relevant of them. Since the discussion above stressed participatory approaches and “cumulative learning by all the participants”, the relationship between “new” professionals and local people is of fundamental importance. This relationship is seen as a “close dialogue” through which new professionals “build trust [with local people] through joint analyses and negotiation”. Since analyses of the problem-situation are conducted jointly, it is natural that the definitions of the problems to be addressed are negotiated as “local people and professionals set priorities together”. This has two consequences. Firstly, since the problems defined and priorities set will reflect the problem-situation experienced by local people, the investigators cannot know in advance where the research will lead; “it is an open-ended learning process”. Secondly, since the problems investigated are not defined within the disciplinary structure of the academic professions, their character is likely to be trans-disciplinary. The mode of working is thus multidisciplinary, “working in groups”, with the group of researchers constituting a problem-determined system.

The style of professional practice advocated by these authors thus depends upon a relationship of dialogue between researchers and local people. The full significance of adopting

such a practice depends upon how the relationship between the landscape studied and its inhabitants is seen by researchers. If they see local people as being essentially separate from the landscape and farming systems being studied, then dialogue with them will be seen as a means of drawing upon their expert knowledge of the system studied. The knowledge gained in this way could, at least in principle, be discovered directly by the researchers themselves (albeit at the cost of spending extended amounts of time on field observation, far more than the time required for dialogue). A realist ontology is thus combined with an epistemological relativism, with the latter representing the 'price paid' for the lower costs in time and other resources of learning in this way about the system studied. However, if local people are themselves seen as being a crucial component of the ecosystem under investigation, then entering into dialogue with them means that "the espoused role and action of the researcher is very much a part of the interactions being studied" [Russell and Ison, 1991, p1]. It follows from this that all such research effectively becomes action research, since measuring something will change it. Nor is this all: entering into dialogue with local people is an implicit acknowledgement of the validity of their view of the world, which is likely to differ from that held by scientists. For Pretty and Chambers [*ibid*] this is tantamount to making the assumption "of multiple realities that are socially constructed". These bold epistemological positions thus provide the cognitive foundations for the new professional practice.

This section, which concludes a review of different approaches to organising research in such a way that its outputs would match the requirements of low-resource agriculture, has outlined various dimensions of a new professional practice. Advocates of this new practice have argued that researchers need to work in this manner if they are to develop technologies that are relevant to low-resource agriculture. Indeed, the practice that they advocate is clearly in conformity with the prescriptions of the 'fifth generation' model of innovation (presented in the first chapter): the definitions of research problems are *negotiated* between researchers and their clients; research teams are multi-disciplinary (formed in response to the problem that has been defined); and research is conducted in the context of application.

The argument of this chapter is that if research is to be relevant to low-resource agriculture then it is essential that it exhibit the kind of approach represented by the 'new' or 'fifth generation' style of professional practice. Since the IARCs have traditionally practised a

radically different paradigm, this argument must call into question their capacity to serve low-resource agriculture in an effective manner. However, the CG System has been placed under sustained pressure to concentrate its efforts upon low-resource agriculture and to demonstrate improvements in the latter resulting from these efforts (impact). The next section will consider these pressures and will briefly review the System's response.

Pressures for Change

As earlier passages of this chapter have suggested, since the early part of the 1980s the donors upon whose support the CG System depends have been signalling their dissatisfaction with the performance of the System. These signals have taken a number of forms. The first has been an end to the period of sustained growth in contributions that followed the 'Green Revolution'. Instead, the core budget of the CG System grew only modestly in the early 1980s (from US\$143.8m in 1982 to US\$173.2m in 1984 in nominal terms) and then began to decline, so that in the period 1989-94 the core funding available to the CGIAR fell by more than 20 per cent [ODI 1994]. Over the same period, however, funds given to support 'special projects' — activities other than those given the highest priority by TAC — increased from US\$28.0m in 1982 to an estimated US\$60.8m in 1991 (in nominal terms). The proportion of total (core and non-core) donations to the System represented by such 'complementary' funding has thus increased considerably, from 12.5 per cent in 1983 to 20.5 per cent in 1991.

The significance of this growth in non-core funding, particularly when considered as a proportion of total donations, is as an indicator that donors no longer agree with the priorities set by TAC. Indeed, rather than simply responding to TAC's advice, they have taken the initiative by asking it to undertake studies on a number of issues; among these have been the implications of incorporating the sustainability perspective into international agricultural research, the need to include additional research Centres in the CGIAR, and how the System should go about strengthening the national research systems in developing countries. One of these initiatives from the donor community conveyed an unambiguous signal about the research direction desired. This was the Group's request that TAC review additional research Centres for possible inclusion in the CGIAR, since many of the ten

selected for this review concentrated upon natural resource-oriented research, while the focus of the IARCs continued to be upon commodity-oriented research.

There are a number of reasons for this dissatisfaction with the CG System. The prolonged period when there were no major breakthroughs resulting from CGIAR research, and in particular not for sub-Saharan Africa, brought discredit to the System. This apparent inability to respond to the food crises of the early 1980s led donors to question the autonomy with which TAC and the IARCs made decisions on research priorities. And this period also saw the Brundtland report and the UNCED summit meeting at Rio; in this climate, donors were becoming increasingly concerned at the environmental impact of agriculture and the need for the CG System's research to incorporate sustainability criteria. The CG System is therefore under considerable pressure to improve its responsiveness in order to regain the attractiveness that it once enjoyed among donors. This means being able to demonstrate an impact upon food production in Africa and in other areas of low-resource agriculture, and addressing the research agenda arising from the impact of agriculture upon the natural resource base.

The remainder of this section will review some of the CGIAR's efforts to respond to these two issues at a System-wide level. Certain of these strategies were reflected in events that took place within CIAT during the period under consideration: this review should therefore serve to place the changes experienced by CIAT within a wider context.

Research for Africa and for Low-resource Agriculture: the need for local-level work

The *1985 TAC Review of CGIAR Priorities and Future Strategies* recognised that there was a need to change the focus of research from agro-ecologically favourable areas towards more marginal areas, primarily in Africa. TAC emphasised that this should bring about changes in the content of research programmes as a result of differences in agro-ecological conditions between (for example) Asia and Africa. The IARCs' directors therefore asked IFPRI (International Food Policy Research Institute, an IARC based in the USA) to produce a report identifying the main problems and opportunities for agricultural research in marginal areas such as sub-Saharan Africa.

This IFPRI report (written by Peter Oram and presented in 1988) distinguishes between areas of different population densities and agro-ecological conditions, and describes the significance of these differences for *farmers'* strategies and for the feasibility of public policy. The report argues that research on the classification of different agro-ecological zones should be of first priority for the IARCs (in the short term, and second priority in the long term). It indicates that those IARCs working from an agro-ecological perspective (that is, within a location-specific or regional approach) have greater relevance to the solution of Africa's problems (i.e. are more likely to have an impact) than those working from a global mandate. Thus, not only resource management but also commodity improvement research should be carried out within a regional perspective in order to reflect specific agro-ecological needs. Further, the report emphasises the link between agro-ecological and socio-economic information about specific areas as a prerequisite for the development of 'win-win' technologies that also encourage equitable distribution of resources among the population.

The IFPRI report thus acknowledges that research at a local or regional level is required for the results of global research to be converted into information relevant to the needs of resource-poor farmers. Such research has traditionally been seen as the responsibility of national, rather than international, agricultural research. However, "the productivity of the international agricultural research system [is] severely constrained by the limited capacity of many national systems" in part because "the adaptation and dissemination of the knowledge and technology generated at the international institutes" depend upon effective national systems [Ruttan 1986, p316]. This means that the weakness of the NARS in much of sub-Saharan Africa, and their lack of interest in servicing regions of low-resource agriculture elsewhere in the developing world, have limited the capacity of the IARCs to demonstrate impact upon the food needs of these regions, even though they are under pressure to do so from the donor community. Ravnborg [1992] distinguishes three possible strategies that are open to the IARCs in response to this dilemma; substitution, by-passing or strengthening NARS.

Substitution

Over the years many IARCs have moved into what would ideally be the domain of NARS by undertaking location-specific adaptive research. This tendency, referred to in TAC

documents as “unco-ordinated decentralisation”, in effect substitutes for national research systems.

By-passing

Under certain (unusual) circumstances, it is possible to develop a technical solution that does not require further adaptation and thus to by-pass the national research systems.

Under normal circumstances, however, this option will not be available.

Strengthening

In general, strong national systems are essential to the CGIAR, not only to adapt the results from CGIAR research but also to identify the problems for which international research is needed. The extent to which the CGIAR should become involved in strengthening NARS continues to be controversial. While TAC's position is that the Centres should primarily be seen as research institutes, a number of donors would like them to become more involved in administering assistance to national research systems.

Sustainability

The 1985 TAC review introduced the concept of sustainability into the CGIAR's statement of objectives, but recommended that resource management should not be incorporated as an independent research area within the CGIAR. Thus, the review urged that certain key research areas in resource management (soil conservation, management and conservation of water resources, agricultural use of energy, and characterisation of agro-ecological zones in order to determine their production potential) should be referred to institutions outside the CGIAR rather than strengthened within the System. Instead, it argued that more emphasis should be given to resource management issues within the framework of commodity or productivity-oriented research³⁷, while collaboration with institutions outside the CG System should be strengthened.

The Review thus re-affirmed the appropriateness of the commodity approach as the guiding principle in the organisation of research, though with a stronger emphasis on multi-

³⁷ The third chapter describes the insuperable difficulties that CIAT experienced in attempting to undertake resource management research within a commodity-oriented framework: see page 111.

disciplinarity. Focusing on a commodity ought to involve other disciplines, and other aspects of the production system such as cultivation practices (which involve resource management, seen as managing factors of production), pest management, and socio-economic issues. The multi-disciplinary commodity approach was thus preferred to discipline and factor approaches to research.

However, this reasoning failed to satisfy the donors, who in 1988 (at the mid-term meeting in Berlin) demanded that more be done to strengthen the sustainability perspective in CGIAR research. So a committee of Centre scientists was set up to review Centre activities in the light of the sustainability imperative and to propose changes required by a sustainability perspective. (When this committee later reported, essentially it recommended continuing existing activities.) Furthermore, TAC's 1985 recommendation that research areas such as the management of soil and water resources should not be strengthened within the System was criticised, particularly since these areas were receiving relatively little research attention from outside the CG System. It was partly as a result of this controversy that, at International Centres Week 1988 (October), the Group (donors) asked TAC to review the position of ten resource-oriented Institutes for possible inclusion in the CGIAR. This request, together with the generous funding enjoyed by the ten, clearly signalled the research direction that the donors favoured. A further hint was that the Group "made it clear that they did not want simply a yes or no decision on each non-associated center, but rather judgements on whether and how the research goals addressed by each of the 10 could best be married with existing CGIAR programs ..." [quoted in Ravnborg 1992 p33]

TAC's position in 1985 was thus that the sustainability perspective should be strengthened in the work of the IARCs by ensuring that it was reflected in all research programmes. However, another way in which this perspective could be included would be to strengthen specific research areas, particularly those relating to resource management, within the CG System. TAC's 1990 proposal that research in sustainable production systems and resource management should be separated from commodity research and undertaken in 'ecoregional entities' reflects this second approach.

Ecoregional entities

These proposals, that the CG System be extended by the addition of what TAC referred to as 'ecoregional entities', are of considerable relevance to the field data discussed in subsequent chapters, since the Natural Resource Division set up at CIAT in 1992 seems to have been designed to fulfil several of the objectives for which the entities were proposed. There can be little doubt that these discussions taking place at System-wide level influenced managerial decisions taken within CIAT.

The establishment of these new institutions was proposed by TAC in 1990. One reason given for this proposal was that the issue of sustainable production systems was said to necessitate research not normally possible in commodity programmes. This marks a reversal of TAC's earlier position, that resource management research can be covered most effectively as an integral part of commodity research. Instead, TAC noted that:

Past experiences suggest that in those Centers that have had both a commodity and a resource management mandate, it has been difficult to strike an effective balance between the two. Generally resource management has received less attention than crop improvement research on mandated commodities. [TAC 1991, quoted in Ravnborg 1992 p38]

TAC suggests a number of explanations for these "past experiences". Commodity research has a longer tradition and so is easier to define than resource management research, while the impact of commodity research is more readily recognised (and demonstrated). In addition, resource management research has such a long time horizon that it is difficult to define priorities. TAC also admits that "the greater emphasis given by Centres to crop improvement research may have been unintentionally encouraged by the 1985 TAC view that the CGIAR Centres should pursue a multidisciplinary commodity approach to research, including research on natural resources ..." [quoted in *ibid* p39]. The earlier position was explained by "the lack, historically, of a holistic perspective vital in the integration of components into appropriate technological solutions".

TAC recognises that the weakness of resource management research that results from "past experiences" has serious implications for commodity research. With insufficient knowledge of resource management issues, it has been difficult to arrive at relevant criteria for commodity improvement as well as for evaluating the impact of the research.

The ecoregional entities are in part intended to address this deficiency. Based in an agro-ecological region, each entity will collect information concerning that region, its farming systems and its resource base. This information will provide the basis for formulating design criteria for commodity improvement programmes and for outlining important areas for strategic resource management research.

Relatedly, the ecoregional entities should participate in commodity improvement programmes, concentrating on applied research. They will function as major testing and evaluation sites for global Centres and have responsibility for adapting new varieties and breeds to existing farming systems. Furthermore, they should host scientists from both the global commodity and subject-matter Centres.

However, the ecoregional entities are primarily intended as the institutional mechanism for carrying out research in resource management and sustainable production systems [*ibid* p69]. It is suggested that these entities should have the primary responsibility for CGIAR research on resource management. This research should be primarily of a strategic character. Finally, they should collaborate with national research systems and help them strengthen their capacity for undertaking research in resource management. They would thus undertake a series of projects that would be “focused on sustainable agricultural development in particular regions; combine natural resource management with productivity objectives; employ a multidisciplinary approach; and involve a consortium of CGIAR and other institutions” [ODI 1994, p4].

There is thus a considerable overlap between the functions proposed for the ecoregional entities and those that are regarded as the responsibility of national research systems. The extent to which the former should become involved in these activities depends upon the strength of the NARS; TAC thus suggests that “Where national systems are weak, a case could be made for the ecoregional entity to take research through all three levels [adaptive, applied, strategic] ...” [quoted in Ravnborg *op. cit.* p66]. Although this document emphasises that adaptive research should primarily be undertaken to develop the methodology and provide an example of how to do it, this proposal raises the possibility that the ecoregional entities could function as substitutes for weak national systems rather than strengthening them. TAC is thus willing to compromise on the CGIAR principle that CG Centres should

primarily conduct strategic and applied, rather than adaptive, research, apparently in order to enable the System to produce a demonstrable impact upon areas of low-resource agriculture.

Conclusions

This chapter has analysed the CG System and its impact upon two types of developing-country agriculture. It has argued that the System conforms closely to the prescriptions of the 'pipeline' model: indeed, that it exemplified this approach to innovation. From this, it follows that not only the structure of the CG System, but the entire experience of the 'Green Revolution', may usefully be interpreted as a practical test of the efficacy of the prescriptions of this model.

The results of this practical test were mixed. Both the success of the CG Centres in achieving their well-defined original goal (that of increasing aggregate yield), and their relative failure in confronting more complex, poorly-defined problems (such as the degradation of the natural resource base and the inadequate livelihoods provided by low-resource agriculture), may be seen as reflecting the strengths and weaknesses of the 'pipeline' approach to innovation. It was argued, moreover, that low-resource agriculture is too important for it to be ignored by research, but that 'Green Revolution' research strategies had been found to be inapplicable to this kind of agriculture. These experiences suggest that while 'pipeline'-type institutions may be an effective means of generating innovations that address well-defined problems, such institutions may be less successful in responding to 'messy' problem-situations where the parameters are poorly defined.

The above generalisation, if valid, suggests that approaches other than that of the linear model (and hence different kinds of institutions from the traditional IARCs) are necessary if the complex problems that are important to resource-poor farmers are to be addressed. This chapter therefore reviewed a range of possible approaches to the closely related problems of poverty among rural people and of environmental degradation in areas of low-resource agriculture. The most promising of these approaches involved research that responded to the demands and priorities of local people and acknowledged the trans-disciplinary complexity of the problems that it addressed. Such promising approaches thus

correspond closely with the prescriptions of the 'fifth generation' model of innovation (presented in the first chapter): the definitions of research problems are *negotiated* between researchers and their clients; research teams are multi-disciplinary (formed in response to the problem that has been defined); and research is conducted in the context of application.

Now, the prescriptions of the 'fifth generation' model have clear organisational implications, which differ markedly from those of the linear model. It is therefore not clear that the IARCs, whose entire approach and organisation has traditionally been predicated upon the 'pipeline' model, will be able to work in a 'fifth generation' manner. Such an adjustment, however, is necessary if they are to address the needs of low-resource agriculture in an effective manner. And addressing these needs has been made unavoidable by the CG System's donors, who have placed it under sustained pressure to concentrate its efforts upon low-resource agriculture and to demonstrate improvements in the latter resulting from these efforts (impact). Some kind of change in the CGIAR is therefore inevitable.

The CGIAR responded to these pressures by proposing to create a number of 'eco-regional entities'. This proposal is extremely revealing, since it amounted to a tacit acknowledgement that the IARCs themselves were not appropriate institutions to develop technologies for low-resource agriculture. In addition to this, the proposed *modus operandi* of the 'eco-regional entities' represented considerable movement towards the 'fifth generation' model. In effect, this proposal was to leave the existing IARCs unchanged while creating a new set of research institutions: the latter, by employing an approach closer to the 'fifth generation' manner than that of the Centres, would undertake key tasks beyond the competence of the IARCs themselves.

Whatever the merits of this proposal, it suffered from one fatal flaw. In a period of financial retrenchment, the additional funds required to create a new set of institutions were unlikely to be forthcoming. While it is possible that many of the donors might have preferred to switch their existing allocations from the IARCs to the new 'entities', they were not offered this option. Instead, the CG System was forced to contemplate a far more radical strategy: that the Centres themselves undertake the tasks demanded by their donors, making whatever structural and organisational changes this required.

The remainder of this thesis will examine the ways in which the themes of this chapter were experienced by CIAT, one of the CG Centres. The history of this Centre will be analysed in terms of a contradiction between its mission and its 'pipeline' type nature. The efforts that have been made to introduce a 'fifth generation' approach into CIAT's work will be discussed, and the organisational forces that resist such efforts will be analysed.

Chapter 3 CIAT and its Mandate: the 'linear' model in practice

Introduction

This chapter will continue to explore the themes considered in the preceding chapter. While that chapter examined the CG System as a whole, this chapter will examine one component of the System, a single CG Research Centre or IARC known as CIAT. The history of this Centre will briefly be reviewed, and will be analysed in terms of an irreconcilable tension between the 'pipeline' type institutional character common to all of the IARCs, and the mandate to serve a specific region that it had been given by the CGIAR, a mandate that required aspects of the 'fifth generation' research practise.

From its foundation, CIAT was obliged by its mandate to undertake research upon a *range* of crops important to the region that it served, and to develop technologies that were appropriate to the conditions under which these crops were actually grown. Knowledge of these conditions, including those factors that would determine the sustainability of the farming systems in question, was seen as being important for this task. A range of organisational mechanisms were therefore employed in order to gather information of this kind and make it available to CIAT's breeders and other scientists engaged in developing new technology. These efforts, however, were constantly inhibited by forces arising from the wider structure of the CGIAR, forces that were apparently acting to enforce conformity to the 'pipeline' model.

This chapter will then consider the various factors that acted to increase the attention that CIAT paid to environmental and resource management concerns. Over the course of the 1980s, the importance that CIAT attached to these issues progressively increased. The manner in which they could best be approached by an institution such as CIAT remained unclear: two distinct approaches were set out in the rival Strategic Plans developed at the very end of the 1980s. These two Plans will be compared: while the first proposed to redirect CIAT's existing Programmes to undertake research that was more relevant to the environment, the second involved structural change, with nearly half of CIAT's total resources being devoted to a new Natural Resource Management division. In effect, it

represented an attempt at a profound shift towards practising the 'fifth generation' model of innovation.

After comparing the two Strategic Plans, the content of the second Plan and the manner in which it was implemented by the Centre will be reviewed. Particular attention will be paid to the Rice-Pastures project, which represented a partial but (I shall argue) inadequate move towards adopting the 'fifth generation' model. This experience was of considerable significance, since it came to represent a paradigm for natural resources research at CIAT and thus profoundly influenced subsequent environment-related work. The manner in which some other parts of CIAT responded to the Strategic Plan will also be reviewed. Finally, the conclusion will explain that these developments provide essential background for the detailed analysis of two linked resource-management projects that occupies the remainder of the thesis.

CIAT and its Mandate

In 1966 the Ford and Rockefeller Foundations, convinced that IRRI had been a success, proposed that a centre of international agricultural research be founded in Colombia. The following year saw the foundation of the International Centre for Tropical Agriculture, generally known by its Spanish acronym CIAT (for *Centro Internacional de Agricultura Tropical*). The foundation of the new Centre was a collaborative venture, in which the Ford and Rockefeller Foundations were supported by the Government of Colombia and the Kellogg Foundation. This was reflected in the selection of Ulysses Grant as CIAT's first director general: Dr Grant, as leader of the Rockefeller Foundation's agricultural programme in Colombia, had helped found both ICA (*Instituto Colombiano Agropecuario*, Colombia's NARS) and CIAT itself. Although the foundation of CIAT was based on the experience gained from IRRI, CIAT was given a different type of mandate. While IRRI had been given a global mandate to focus upon rice,³⁸ CIAT (like IITA, which was also founded in 1967) was given a regional mandate; to conduct research upon many commodities, but only within a specific region, the low-lying tropics of Latin America.

³⁸Similarly CIMMYT, founded in 1966 on the basis of the maize and wheat programmes begun in the 1940s by the Rockefeller Foundation, was mandated to conduct global research upon wheat and maize.

In order to fulfil this mandate, CIAT began its work by investigating a range of commodities important in the region that it served. From the establishment of the first Programmes (in 1969), it was clear that the Centre was seeking to respond to the needs of both large-scale and resource-poor farmers. As was the case at other CG Centres, each Programme housed practitioners of the 'classic cluster' of agricultural sciences, grouped around commodity breeders (see page 55). The 21 principal staff then employed were thus divided between six Programmes, ranging from Food Legumes and Tropical Root Crops, to Rice.³⁹ This division, between those who work for resource-rich farmers and those who endeavour to serve the resource-poor, has lasted throughout the Centre's history and now extends throughout CIAT from the Board downwards. Perhaps reflecting the dual character of the societies that CIAT serves, it has introduced a fundamental ambiguity into the Centre's mission.

From its beginning, then, CIAT's work has included the development of improved varieties of staple crops adapted to the lowland tropics of América: a Land Management specialist even suggested that its foundation as an agro-ecosystem centre represented a reaction against the 'Green Revolution' experience. "We recognised that things were wrong [with applying the 'Green Revolution' approaches (exemplified by CIMMYT's work with maize) to 'minor crops', such as beans]. You can't assume that farmers are going to be in a position to put fertiliser on and irrigate it. But if a commodity breeder does not have the same control over the conditions under which his crops are grown that 'Green Revolution' breeders could assume, then he needs to know where his crops are going, so that he can tailor a variety to a particular climate, soil type or even cultivation practice." Efforts were therefore made to learn about the conditions under which these 'minor crops' were grown in this region so that breeders could produce varieties that perform well under these conditions.

The manner in which CIAT interpreted its mandate meant that two distinct types of organisational unit were required. On the one hand, each of the six Programmes

³⁹In Colombia and much of Latin America (unlike Asia and Africa) rice is generally grown on farms that are relatively large and well-resourced. The 'culture' of CIAT's Rice Programme reflects these user characteristics, although it is clear from Leurquin [1967] that at the time of CIAT's foundation rice was also a small-farm crop in parts of Colombia. As well as the three listed above, CIAT's original Programmes included Beef, Corn, and Swine.

investigated a *discrete* commodity, so that for each Programme the system of interest consisted of the plant or animal species in question. In this respect the work of the Programmes conformed to the 'abundant resources' methodology (see page 68). However, rather than seeking to maximise performance of the commodity in question under *optimal conditions*, the Programmes sought to do so subject to certain parameters corresponding to the *environment* of their system of interest, in effect representing the constraints imposed by the actual conditions of production. In order to set these parameters, organisational units whose system of interest constituted the *context* of commodity production were required. Such units would necessarily undertake research at a level of complexity higher than that of the discrete commodity. A range of organisational mechanisms, each corresponding to a different definition of the higher-level system within which commodity production takes place, have therefore been employed to complement the work of the Commodity Programmes. The discussion that follows will consider CIAT's experience with three such mechanisms — the programme of Farming Systems Research, the IPRA Project (farmer participation in research) and the Agroecological Studies Unit — and will highlight their part in CIAT's development.

Farming Systems Research at CIAT: the experience and its lessons

CIAT's first attempt to undertake research upon a system defined at a level of complexity higher than that of discrete commodities was the Programme of Farming Systems Research undertaken in the 1970s. This Programme tried to work on everything that could be produced in the environment of interest to CIAT, "but still with a commodity orientation". As a result, this Programme "wound up working on swine, sheep, all the legumes, practically all the root crops, everything you could think of. It just wasn't efficient [so then] we decided to concentrate on certain things that we were confident that we could do reasonably well." Dr Laing, a former Director of CIAT who had witnessed these events, recalled that it "had a warring party within it because everybody had different views on what it should be doing, we had ducks running around CIAT, it was a zoo of ideas and of action". He judged that it "failed completely because it couldn't find a focus for its activities. ... In the end it was disbanded." Another interviewee explained this lack of focus on the grounds that "the systems were too complicated" and that "there was no clear methodology".

Dr Laing believed that CIAT learned three lessons from this experience:

1. the necessity of concentrating efforts upon a limited number of problems;
2. the location-specific nature of research on sustainable farming systems; and
3. the need for farmer involvement in this kind of work.

The first lesson led directly to the establishment of CIAT's four Commodity Programmes, which undertook the bulk of CIAT's work throughout the 1980s. The Programmes concentrated, respectively, upon Beans, Cassava, Rice and Tropical Pastures. These commodities had been chosen because of their contributions to both the diets and incomes of not only resource-poor farmers but also consumers throughout América. There were fundamental differences between the 'constituencies' served by these four teams: the Rice and Pastures Programmes were oriented towards the needs of large-scale farmers, while the Bean and Cassava Programmes concentrated upon the resource poor.⁴⁰ Another significant difference was that the latter two Programmes held global mandates and so were expected to serve bean and cassava users throughout the world, while the Rice and Pastures Programmes could confine their attention to América south of the Río Grande.

Sustainability research: excluded by the 'pipeline' model?

The second lesson was that the results of research on developing sustainable farming systems may vary "valley by valley, hill by hill". This factor limited the applicability of the kind of research that can be performed within an international Centre, so during the eighties environmental problems were addressed by out-posting agronomists to the external Programmes. "So we had three agronomists in the African Bean Programme, working on locally-specific problems with national programmes. The idea was that the locally-specific problems were to be researched by the locals, but with the help of CIAT in the regional Programmes. Agronomists were outposted to be close to users, who were both farmers and national programme collaborators. They were working hand in hand with breeders and pathologists to develop farming systems that were sustainable. ... [We felt that many] of the technological components would come from that more diversified research, less focused on

⁴⁰ At least for its first decade, the main impact of the Cassava Programme was upon large-scale farmers, but this occurred in spite of the best efforts of its members.

headquarters. [However], I and many others felt that we needed a Programme [at headquarters]" to support these efforts and to develop methodologies for them.

This lesson learned from the failure of the Farming Systems Programme informed the efforts made at the end of the 1970s to develop a long-range plan for CIAT. Research related to sustainability was seen as being primarily the responsibility of out-posted staff, but a range of activities at headquarters were necessary to support such research. However, such activities did not fit into the Centre's established structure, while their close relationship with 'location-specific research' meant that they were apparently excluded by 'pipeline'-based definitions of the role of research at headquarters. Dr Laing felt that "we had all been suffering, because there was nowhere to place things like ground-cover to stop erosion. There were some technological components (like this) that just didn't fit in any of the Programmes. So we used to draw up little Special Projects, but none of that really worked out well. Unless you have a central force within your organisation doing something, it just doesn't get done. You can't expect it just to happen on the edge of things. ... And also there was soil science: for various reasons we started off at CIAT with lots of excellent soil scientists, but we couldn't find a role for them in the organisation." This was serious, he believed, since "soil is the nub of sustainability" so that "soils and their maintenance are the key issues". However, instead of looking at the soil itself, soil scientists were "looking at the plant and its adaptation to those soils" since they were given "jobs like testing plants for acid soil tolerance". As a result of this limited definition of their role, they "kept on being kicked out of the Commodity Programmes by what seemed natural forces". The new structure proposed in the first long-range plan was intended to address these organisational constraints.

Dr Laing, then a member of the Bean Programme, chaired the first long-term planning committee. He explained that: "The Plan [produced by this committee] was based on the concept of two divisions at CIAT, one division on Crop research and a division on Land research. Land research was to include not only the Pastures Programme but also research on soils and environment." This Plan represented a considerable departure from the role that the CGIAR as a whole had defined for itself: as mentioned in Chapter 2, while the 1985 TAC Review was to introduce the concept of sustainability into the CGIAR's statement of objectives, it recommended that resource management (explicitly defined as

including soil management and conservation) should not be incorporated as an independent research area within the CGIAR. Nevertheless, the Plan was presented to the meeting of CIAT's Board held in April 1980, but was opposed by the then chairman, a German who represented GTZ. This individual argued that the Plan represented too great a departure from established practice. His opposition proved decisive, and so the Plan was rejected by the Board. He later revealed to Dr Laing that he had made this decision "on the basis that GTZ would not like it, although he said that he liked it. He told me many years later: he had consulted with GTZ before he made the decision, and they turned down the Plan. So one donor redirected the whole of CIAT." The CGIAR structure (albeit animated by a single donor) had thus maintained CIAT's conformity to the orthodox practice prescribed by the 'pipeline' model, even though the Centre's attempted 'heresy' resulted from its efforts to fulfil its mandate.

Following this rejection, "we had to go back to the drawing board and come up with a plan that didn't include that new division". As a result, CIAT's organisation continued to be based upon the four Commodity Programmes. For Dr Laing this structure did not really accommodate work on environmental issues and efforts to develop sustainable production systems: "So then we went on our course during the 80s, still struggling to find places for these [activities], doing them, but soil scientists continued to lapse because we moved them all out, we tended to move them out to external Programmes [in other countries], we constantly lost soil scientists because we couldn't find a role for them within the agreed structure." This state of affairs continued until the end of the decade.

CIAT, then, had felt a need for a permanent organisational structure that would undertake research upon systems (soils and environment) that were seen as constituting a context within which commodities were produced. Such research had been perceived as important in facilitating the (location-specific) development of sustainable farming systems, so that the need for research at a level of complexity higher than that of the discrete commodity had been linked to environmental concerns. However, the conservatism of the CGIAR limited the manner in which CIAT was permitted to act on this insight.

Farmer Participatory Research: the IPRA Project

The third lesson arose from the acknowledgement that farmers, with their own concerns and preferences, constitute an important part of the environment within which CIAT commodities are produced. One way of perceiving a system of interest that constitutes the context of commodity production is thus to concentrate upon the farmers themselves. Such a definition of the system of interest led in turn to a conceptual leap: the realisation that the difficulty posed by the location-specific nature of much of the work done by the Farming Systems Programme was exacerbated by this Programme's inability to draw upon farmers' knowledge of their local environments. Instead, researchers (socio-economists as well as agronomists) managed their on-farm work "in complete isolation from the farmer". For Dr Laing, this Programme "failed because we didn't include the farmers in the process". The third lesson from this experience, then, was "the realisation that working at CIAT headquarters in environmentally-related research, where the end-user was the farmer, was a bit difficult because we were too far from the small farmer". It led to "a felt need to find a way to reach the small farmer rather than doing huge programmes at headquarters, because lots of the environmental research was very location-specific".

It was at this point that Dr Ashby proposed a new project "to develop some ideas on how to do on-farm research, how to do sustainability research, and how to get the farmers involved. [Her] idea of listening to the farmer wasn't new, but it was something upon which we needed to focus in new ways: it was deficient in CIAT. And finding a method to approach farmers and to encompass their ideas into the research programme, that needed work. ... At that time there were a few ideas floating around, but not many people had actually tried them. ... She had presented her ideas very well and we agreed with them, so the project was developed, by Jacqui of course but with strong support from headquarters, including myself and Nores.⁴¹" The support of the Ford Foundation was also very important in legitimising this project, which might otherwise have been seen as too location-specific for an international Centre.

⁴¹Dr Gustavo A Nores served CIAT as a Director in the early 1980s. In 1990 he returned as Director General.

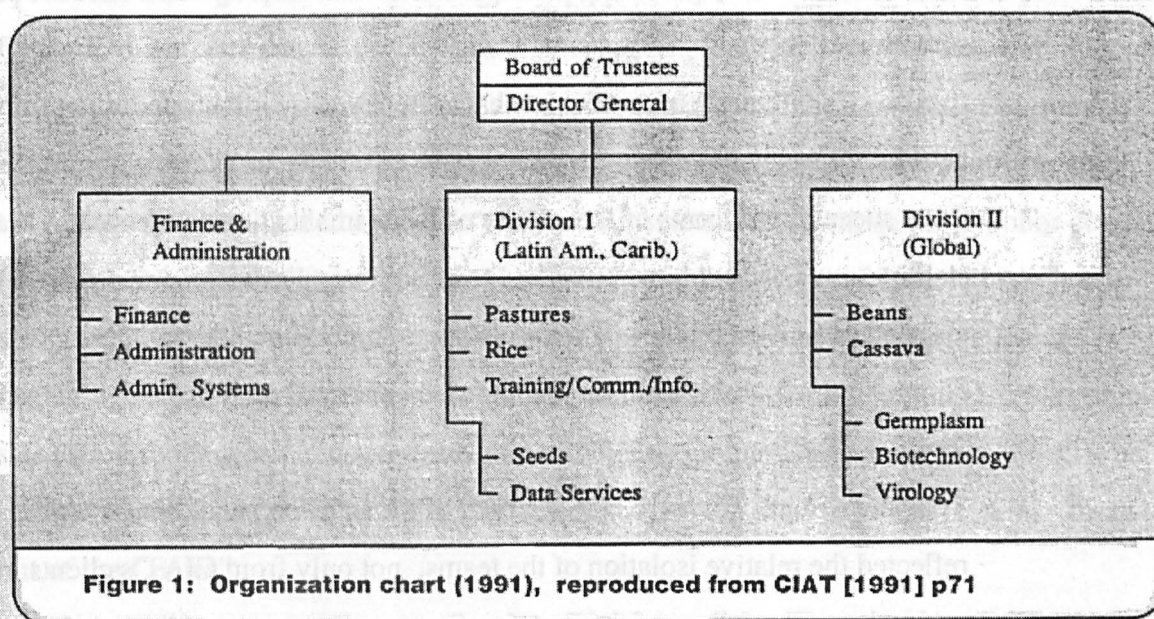
This project essentially involved the development of methodologies for involving farmers in the evaluation, first of fertilisers and then of crop varieties. These methods are relevant to various researchers: at CIAT they were developed to aid commodity breeders concerned at low rates of adoption for the varieties that they had produced and were later applied to natural resource management. Initially they were seen as a simple solution to the problem of predicting how farmers would respond to new technologies. This solution essentially involved farmer participation in the design of new technology. Dr Ashby recalled that these experiences led to a “flowering of social sciences at CIAT” as “Programme leaders began to get excited about social sciences — they saw that this was the way to tackle the adoption problem”. As a result, social scientists came to be seen as important members of the team, while the Programmes developed a “whole culture of [interdisciplinary] teamwork”.

This work on methods of farmer participation in research continued to be organised as a special project (free-standing, not housed within a Programme) with its own staff and resources, since it did not ‘fit’ into any of the commodity-based Programmes. The years 1987 to 1990 saw the development of a full-blown methodology for this research, together with the production of training materials to pass on skills in these methods.

Since the beginning of the 1990s, CIAT’s research on farmer participation has concentrated on finding ways to build, within the *community*, the capacity to carry out research. This is intended to make it possible for the process of research to be driven by *demand from clients*: the researchers within the community will inevitably encounter problems that they are unable to solve, and so will demand specific assistance from professional researchers. The CIAL method, which forms committees of farmers who are interested in doing research and links them with professional researchers, is used to build this capacity. This method may be seen as a way of creating mechanisms to ensure that the needs and priorities of clients are known to researchers at an early stage in the development of new technologies. In effect, it is a process of building social institutions that will be able to exert effective demand for research. The task of the researcher is then reactive, to develop new technologies that meet these needs. These experiences were later to provide a basis for the approach of the Hillsides Programme, which was to be staffed by many of the people who had worked for the IPRA project.

The Development of the Commodity Programmes

From their foundation in the mid-seventies until the beginning of the nineties, the four Commodity Programmes constituted the basic unit of organisation within CIAT (see Figure 1 below). It is therefore important to consider their composition and approach, as well as their relationships with each other and with their immediate organisational environment.



As mentioned above (page 110), each of the Commodity Programmes concentrated on breeding improved varieties of a specific crop and thus included practitioners of the various agricultural sciences that made up the 'classic cluster' (page 55). They were later joined by economists and other social scientists: following the eventual closure of the Farming System Programme, its economists were placed in the Commodity Programmes (one in each), which also gave intermittent employment to other social scientists. Later, once the IPRA project had demonstrated that social science could contribute to increased rates of adoption, a culture of inter-disciplinary teamwork developed in each of the Programmes. Thus Anderson *et al* [1988 p69], in their review of policy research throughout the CG System, noted that: "In the *commodity* approach, adopted only by CIAT, social science research is incorporated into the work of multidisciplinary teams that address a particular subject or commodity, such as tropical pastures, beans, or cassava." Breeders were now provided with information about the environments in which their crops would be grown by specialists in the relevant disciplines attached to their Programmes.

Throughout the 1980s, then, the main 'business' of CIAT was commodity breeding: this was undertaken by the four Programmes, assisted by a number of smaller entities including the IPRA project and the Agroecological Studies Unit (see below). Many people within the Centre recall this period as one of sustained achievement. For Dr Laing, for example, who had served as a Director throughout the decade, "the 1980s were very successful ... we had a ferment of activity and we had adoption of our technologies all over the place. Every day something happened that made us feel good. ... If you look at CIAT's 1980 plan and our results, we did much more than we had planned to do, we found more things, because we couldn't possibly have foreseen how productive those ten years would be." He explained these successes in terms of the quality of the teams that made up each of the Programmes, stable groups of people who worked together over periods of years and so came to trust and understand each other. The results were impressive: "if you give a team, which is compatible with each other, a job to do, then they'll do it".

To some extent, however, the strength of the inter-personal bonds within each team reflected the relative isolation of the teams, not only from CIAT's clients but even from each other. The failure of the Farming Systems Programme (discussed above) had highlighted the gulf between research at CIAT headquarters and the small farmer, a gulf that resulted (for example) in very limited adoption by small farmers of the cassava varieties produced at CIAT.⁴² While this was perceived as a problem, both the separation of scientists from donors and the divisions between the Programmes apparently resulted from conscious policy decisions made by the then Director General, Dr John Nickel.

Dr Nickel served CIAT as Director General from 1974 until his retirement in 1989. He had previously been the Director General of IITA, an appointment that was preceded by a long and distinguished career within the CG System. It was therefore natural for him to subscribe to the assumptions about the role of research upon which the work of the IARCs

⁴²The adoption problem faced by the Cassava Programme stimulated research on the quality characteristics required by users: this work marked the beginning of the process that led to the IPRA project and the development of methodologies for farmer participation in the research process. (This work later revealed that the decisions made by small-scale cassava farmers in many regions were based on factors that the researchers had not suspected.) The apparent inability of this Programme to develop varieties attractive to small farmers led a former Head of CIAT's Impact Assessment Unit to disagree with the view that CIAT had been particularly effective in the 1980s.

and the Rockefeller Foundation had been predicated (discussed in Chapter 2 above). This conventional wisdom has been summarised as a strategy of basing a group of competent scientists in a developing country, providing them with excellent facilities, and isolating them from political pressures, so that they could get on with the job of developing valuable new technologies.⁴³ As Dr Laing recalled, “John Nickel ... thought that he had a highly-trained group of elite foreign staff who had parachuted in here to solve the problems and that all the other people were natives. That [approach] was successful in other parts of the System, it was the reason for the ‘Green Revolution’, that’s how it worked, but in the modern age it’s a little *passé*.” Thus, as a leading member of the Lowlands Programme explained, his philosophy “was to give the scientists the means to do their jobs [so that] ... the money was just handed over”. In effect, he insulated the scientists from donor concerns (seen as being essentially political) so that even in 1996 it was possible to say “there are scientists here who do not know how to write a project proposal”. This practice of insulating researchers from the needs of their stakeholders was clearly intended to promote scientific excellence. However, as a leading scientist pointed out, doing this “results in a technology-driven style of working: the scientists develop their lines and then take them out of the Centre”.

Another traditional spur to excellence is competition, so “John Nickel wanted to have the Programmes competing with each other [which meant that] there were a lot of walls put up between the Programmes”. Thus, as a leading member of the Lowlands Programme explained, until 1992 CIAT had always been four distinct Programmes, “almost four centres in one, where there was little interaction between the Programmes: they all had their separate fiefdoms, which still exist. So there were a lot of walls put up between the Programmes.”

This state of fragmentation has persisted for a number of years. In 1989, an internal investigation of CIAT’s culture revealed that the principal staff were concerned at the lack of cooperation between Programmes. They felt that they did not know what their colleagues in other Programmes were doing, and that this ignorance led to much

⁴³This paraphrase of conventional wisdom around 1970 was provided by one of its critics. RL Sawyer, CIP’s founding Director General, served for less than five years before resigning in frustration. See Horton [1991] p222.

destructive criticism.⁴⁴ However, changes to this situation have historically been resisted by the Programme leaders “who have driven things here”. The senior scientist quoted above argued that “they are conservative and feel that they have to defend their Programmes and stick to their mandated area. They feel that if their scientists get involved in other commodities then it becomes more difficult to demonstrate the impact of their Programmes. They perceive this as a threat to their Programmes ... and so tend to put up walls.” Speaking in 1995, a former Leader of the Bean Programme thus described the Programmes as being “fiercely autonomous”. Another senior scientist, who had joined CIAT in mid-1994, compared the Programmes to “islands”. While he had made efforts to divide his time between different Programmes this had not been understood: he felt that Programme leaders were reluctant to accept a part-timer as a full member of the team.

The Commodity Programmes, then, were isolated from their clients and stakeholders, from most other institutional sources of expertise, and even from each other. In the absence of such external sources of direction, they worked in a technology-driven fashion. They thus conformed closely to the ‘pipeline’ model of innovation, and since the power of their Leaders depended upon maintaining the *status quo*, powerful organisational forces acted to resist any change to this situation.

Support for the Programmes

Despite the culture of isolation that has characterised the Commodity Programmes, their need for specialist support services was recognised at an early stage. As argued above, compliance with CIAT’s mandate involved obtaining and using information about the environments in which crop varieties developed by the Centre would be grown. It was to provide breeders with this kind of information that the Land Management specialist (quoted above) first joined CIAT: “I came in 1978 to do a climate survey for the bean team ... so that they could set their research priorities.” He began to collaborate with a colleague attached to the Pastures Programme. Realising that their work was relevant to a range of questions faced by all of the Programmes at different times, they “made a conscious decision to put all the information that we were getting into readily accessible databases.

⁴⁴The findings of this study were suppressed immediately after the appointment of Dr Nores as Director General, so no report was ever written. However, the Deputy Director General responsible for Finance and Administration, Dr F Kramer, discussed some of the results with a meeting of the principal staff. His presentation was recorded, and a transcript of this tape was later obtained by the present author.

We worked together for a number of years, creating the soils terrain database, the climate database, and I started on the crop distribution database. Eventually the Agroecological Studies Unit grew out of this work.”

The information generated by this Unit was indeed of value to all of the Programmes. Once the three databases had been created, it became possible, by combining them, to specify the research priorities for any given commodity. The same databases made it possible to identify homologous areas (different areas where the same varieties will grow well). The Unit thus functioned as an information service for the commodities. As with the earlier proposal for a Land research division (page 111), the Agroecological Studies Unit was needed by the Programmes to enable them to fulfil CIAT’s mandate in an effective manner, but could not readily be supported by the CGIAR’s usual arrangements for allocating resources:

Originally there was quite a lot of opposition [to our work]. They didn’t see why they were wasting money on something that didn’t produce a concrete output, but just information. However, some of our successes eventually [provided the justification to get more resources from within CIAT and so to work on a larger scale.] And we tried very hard to secure external funding: we submitted applications to the major donors explaining why these databases would help CIAT work. The response was always the same: saying that the proposed projects were so important that they should be financed from CIAT’s core budget. Up to then this work had been financed with post-doc funds [and then with a succession of equally short-term contracts].

As a result of these difficulties, it was only in 1983 that this work began to be supported on a more secure basis with the formal establishment of the Agroecological Studies Unit. Over the following five years “we had a good run serving the commodities” and accumulated “a tremendous wealth of information in the databases”. It was at this point that the need for conscious consideration of the environmental consequences of different land use options became apparent:

That [1988] was when we finally realised that working only on commodities was not having any effect on resource management or the impact of agriculture on the environment. We really had to look at resource management from the other direction. Up to then we had been looking at the environment and its effect on the crop: at that point we decided to turn it round and ask about the effect of these farming systems upon the environment, how can we develop farming systems that don’t have too deleterious an effect upon the environment.

Answering this question was to plunge the whole of CIAT into a period of profound change, as we shall see.

Environmental Issues command increased attention

Throughout the 1980s, the attention paid to the environmental impact of agriculture and to questions of the sustainable management of natural resources increased steadily. A number of the scientists interviewed stressed that the Commodity Programmes, throughout their history, had always engaged with these issues. The natural development of these Programmes, together with increasing indications of environmental stress throughout América (amplified by new tools that made such stress more visible), led to greater involvement with questions of natural resource management (NRM). At the same time, CIAT's donors were signalling their desire to support work directed to the management of the environment. This donor pressure was later supported by the personal interests of part of the senior management team that held office in the early 1990s.

Dr Laing argued that from their foundation each of the Commodity Programmes “had environmental research embedded in it, not specifically looking at the environment *per se*, but looking at the crop within its environment” and so “we felt that the Commodity approach on its own was doing a tremendous amount for the environment”.⁴⁵ This environment-related activity reflected the importance of ecological concerns to the Centre's immediate surroundings: he cited “the massive degradation of the Andean agricultural systems, in which we are located” as one reason for this activity. He described this degradation as “palpable: they were sitting there waiting for us to respond [but] ... we weren't doing anything about it. That was there from the very beginning: ... my predecessor as Director of Research was particularly concerned about that and I inherited that view from him: ... we had to do something about it, but how?”

As well as “the evidence all around us of the deterioration of agricultural systems”, Dr Laing was disturbed by the migration of small farmers to the cities. “We knew that a lot of them were leaving because of environmental reasons, because they just could not survive on their farms any longer. Large areas of the Andes were so eroded and destroyed that people could not survive on their farms. That was another reason why we focused more on

⁴⁵ Dr Laing also made it clear that at the end of the 1970s CIAT's senior management team thought that the “tremendous” contribution made to environmental management by the commodity approach “was not enough, so that was why we developed this plan for this Land Resource Division”.

environmental research. We knew about it all the time, and that 's why we were doing it within the Programmes."

New tools, particularly geographical information systems (GIS), added precision to these impressions of ecological crisis and helped to define ways in which CIAT could respond. "For the first time, GIS allowed us to analyse the environments in a global sense, we could answer questions like, where are all the acid soils, what are their conditions, so geographically we could analyse the environments at which we were aiming our technology. So we could understand the problems better, helping us to devise research programmes. It also enabled us to target our technology for the needs of the area at which it was aimed. So the input from GIS provided us with a new tool, something that fitted in very well to support both commodity and environmental work. Joining up the two was ideal: GIS made us realise that there were new tools out there which would help us to transfer ideas from just commodity research to environmental research."

Programme Development

The Rice Programme

Information on the degradation of the Américan environment also guided the natural evolution of the Commodity Programmes towards an increased sensitivity to the environment. The Rice Programme, for example, began with a narrow focus upon increasing production in the region. Once this initial objective had been achieved, other things were examined. One of these, as a rice scientist explained, was "to increase the efficiency of rice production [which] involved looking at diseases of the crop and [the adverse consequences of using high levels of inputs, in terms of environmental damage, high prices, and limited sustainability of the system]. We had indications of indiscriminate use of fungicides and insecticides in Latin America."

"The Programme became conscious of that particular problem for [two reasons]. One was that the indiscriminate use of chemicals was damaging the environment, and particularly from the entomological point of view we saw that this was exacerbating the problems caused by other insects. On the other side, this use of chemicals resulted in an increase in the price of rice, while one of our main objectives is to produce low-cost rice for low-

income consumers. [So for all these reasons we wanted to develop] materials that are less dependent on the use of chemicals." She stated that as a result of these considerations, her main interest is "to aid the development of germplasm adapted to agro-ecosystems, and thus to develop materials that will be less dependent on chemicals (fertilisers, fungicides, pesticides, etc.)."

Similar concerns may have contributed to the genesis of the Upland rice-breeding programme, whose main objective was to develop lines of germplasm that were adapted to grow under acid-soil conditions (savannahs). These varieties open up possibilities for rice-pasture rotations in the savannahs, where the rice harvest pays for fertiliser and cultivation so that in effect there is no cost for restoring the fertility of old pastures or opening up new ones. (The project that developed this system will be discussed in greater detail below, from page 138 onwards.) It is therefore possible to interpret the development of these rice varieties as a contribution to the management of these environments.

The Cassava Programme

The development of the Cassava Programme also involved engagement with questions of natural resource management, as its Leader explained. "The potential of the germplasm [that we develop] will not be realised unless you manage the environment that surrounds the plant." He rejected chemical-based methods of doing this, since "cassava is a small-farm crop, and remains in the field for a long period of time, so the possibilities of controlling the environment by 'Green Revolution' methods are limited. And at present the crop does not use a lot of agro-chemicals, so it would be a mistake to move towards that if it were possible to move away. Instead, we feel that there are forms of cultural and biological control that can be employed to attain the potential of the germplasm."⁴⁶

⁴⁶This rejection of chemical solutions may be compared with the following passage, published as recently as 1988, which represents a more traditional CGIAR approach: "Large-scale farmers in Colombia achieved high cassava yields through monoculture while nearby small farmers who used complex multicropping systems produced small yields. The initial reaction was to call for cassava varieties tailored to the small farm. ... [Later] it was learned that the small farmers used a multicropping system to reduce their need for pesticides ... [because they] could not borrow the money they needed to buy pesticides. It is conceivable that [measures to liberalise the market for agricultural credit that could improve small-farm access] would raise output on small farms sooner and more substantially than would the development of a new type of cassava." [Anderson *et al*, 1988, p68]

These considerations provided the rationale for the work on integrated crop management, the third of the five projects that were being implemented by the Cassava Programme in the mid-1990s. Integrated pest management and integrated crop-soil management were the two basic thrusts of this project, and also the integration of the two. The outputs that were sought took the form of biological and cultural control practices that would enable cultivators to maintain fertility and control erosion in cassava-based cropping systems. As the manager of this project explained, the Cassava Programme had always been active in this area. Such activity had been necessary because cassava is traditionally grown on marginal soils, so that fertility management is very important for the farmers concerned.

These efforts moved forwards in the mid-1980s, when this Programme sought finance for a project that would develop sustainable cassava-based cropping systems, with sustainability mainly being investigated with respect to erosion. The Programme's Annual Report for 1987-1991 [CIAT 1992 p209] explains that:

To strengthen this research effort a collaborative research project was initiated with the University of Hohenheim, Institute for Plant Production in the Tropics and Subtropics, Germany, in 1986 ... The project has focused on

- a) collecting fundamental data on soil erosion ... and
- b) evaluating different cultural practices in relation to soil erosion and productivity.

The Commodity Programmes, by conducting research on their mandated crops within their respective environments, were thus devoting a large and increasing share of their attention to resource management questions. There was therefore a certain amount of justification for the claim that they later made, that they offered an appropriate cognitive and organisational structure for the conduct of environment-related research.

Donor Pressure

Despite the importance of these developments within the Programmes, Dr Laing stated that "the pressure [for the move into Natural Resource Management] came from the donors, definitely. The donors were putting pressure on the System to change from purely commodity research." This view was confirmed by a number of the CIAT scientists interviewed, and was expressed most forcefully by a senior member of the Rice Programme: "My personal feeling, and the feeling of some of the staff at CIAT, is that some of these changes that we have seen at CIAT have been results of donors wanting us to

make changes in direction, without considering our thinking or our feelings about changes.” A member of the Bean Programme added that “five or six years ago natural resources were not a priority, but since the donors have changed in that direction CIAT has to respond. ... In a way the whole of CIAT has changed. It is not so much commodity-oriented but is now balanced between commodity and natural resources research, and much of that work is due to donor pressure.”

A former Programme Leader confirmed that to a certain extent the new work in natural resources had been seen as a means to finance older-established work. “We were originally counting on the ability of resource management to attract money to maintain the Commodity Programmes, apart from transferring some of the agronomists over to the ecosystem work — a few re-positionings. We hoped to keep the whole of the strength of the commodity side there, but it hasn’t worked like that.” In fact, “we suddenly started getting funds earmarked for resource management, too quickly. These were funds that the Commodity Programmes would have been using, and they were just switched to us.”

The two Strategic Plans for the 1990s

CIAT’s move into natural resource management (NRM) research thus appears to have resulted from the convergence of various factors: increasing evidence of environmental stress in the region that it serves; the natural development of the research pursued by its Programmes; and a shift of donor priorities towards environmental issues. One possible response would have been to accelerate the incorporation of a natural resource perspective into the existing Programmes that was apparently already taking place in a natural manner. This was the approach outlined in the 1989 Strategic Plan [CIAT 1989], which proposed to retain the commodity focus but to add new objectives to the goals pursued by the established Programmes. An alternative response is the choice of structural change as the means to implement a change of mission, making possible a move to an Ecosystem focus. The 1991 Strategic Plan [CIAT 1991], which followed the appointment of a new Director General, was based on this latter approach and involved the creation of new Programmes to pursue the new objectives.

The preparation of these two Strategic Plans involved an extended period of uncertainty for CIAT. This period was painful, not only because of the uncertainty but also because, as Dr Laing explained, planning itself (at least as practised within CIAT) "is a terribly disruptive, debilitating business". Research work is suspended to make way for an activity that, he believed, is seen as being essentially futile, but required by powerful (and despised) bureaucrats. "Some [agricultural research] is pedestrian and you can more or less predict the outcome, but ... the result of good research is unpredictable. ... I always felt that ... once you had a good mission and some good objectives, without being too specific, you had to try and run with it and you'll get there. ... So in a sense planning for research is redundant before you start, but we are expected to do it [by] ... the bureaucrats in Washington ..." This situation meant that "while I was involved in long-term strategic planning at CIAT for years, my heart was really not in it". Indeed, the process of preparing detailed plans "used to make me feel sick inside. The point was, nobody ever bothered to look at the plans [after they were ready]." The legacy of this process is a general dislike of meetings and discussions that are now seen as distractions from 'work', which is usually performed in the laboratory.

The 1989 Plan

The planning process began in 1989. As Dr Laing explained, John Nickel, who had been CIAT's Director General (DG) since 1974:

was considering leaving, not because he wanted to go but the Board thought it was time for a change, although he was an excellent leader. ... Should he write a plan before he left? ... He wanted to influence the next DG: he didn't want somebody to take over and put CIAT onto a completely different track, so I think he persuaded the Board that a Plan should be written before he left. ... In the end, the Centre decided to go ahead with a new plan, under Nickel."

The result of this process was the 1989 Strategic Plan, which sought to strengthen the natural resource perspective within the work of the four Commodity Programmes. Thus one reads that "CIAT commodity programs already make a major contribution to sustainability through their efforts to increase crop productivity ... In addition to their pivotal role in enhancing productivity through germplasm improvement, the commodity programs are making major contributions by developing component technology for cultural practices which make possible more sustainable systems." After a brief discussion of the importance of germplasm conservation and management for NRM, the Plan informs us that "concerns such as genetic diversity, cultural practices, misuse of chemicals and intensifica-

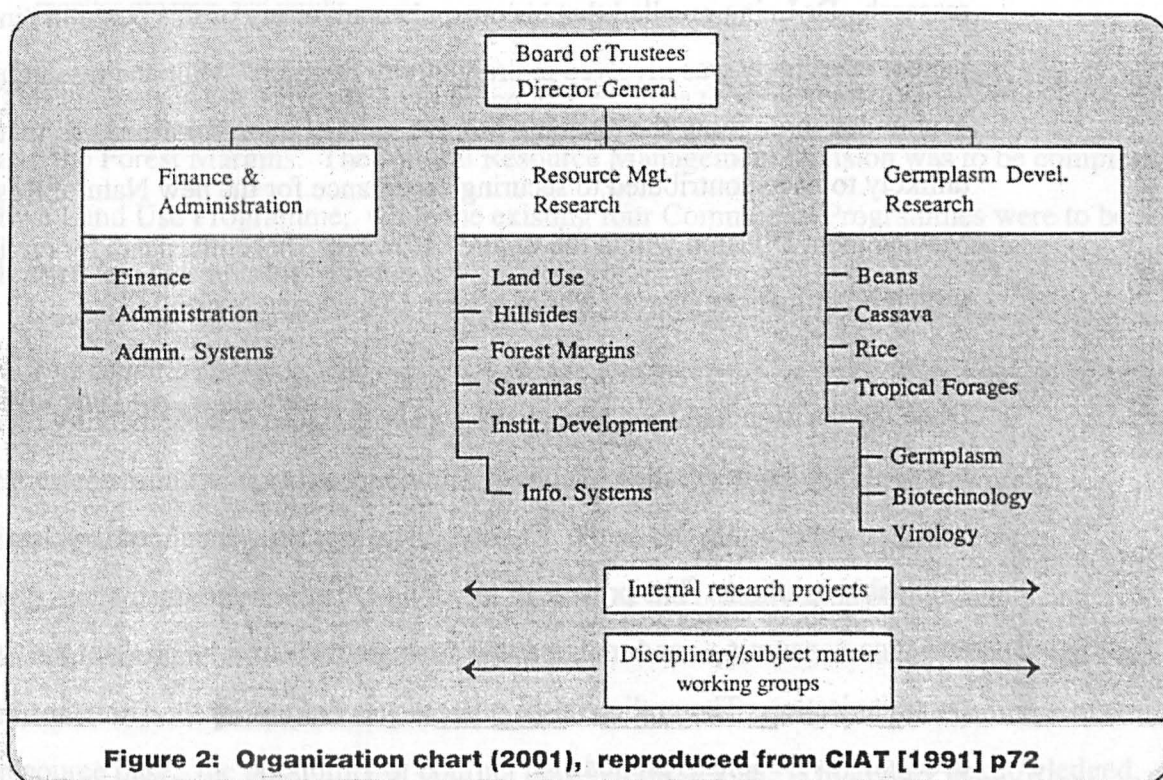
tion of production can be best dealt with by the commodity programs [which] develop component technology for use in existing farming systems.” [CIAT 1989, pp19-20]

For Dr Laing, this Plan “was not soft on environmental research, but in my view it was not a practical approach to the problem ... It was still a problem: how does an international Centre get involved in sustainability research. And we developed this Plan which was probably a soft option.” Hidden in this Plan, however, was a tentative proposal to create “a new program to deal with natural resource issues for one or more ecosystems” [*ibid* p21], since the Commodity Programmes “do not have a comparative advantage in developing new farming systems, nor are they equipped to work effectively on broader issues at the ecosystem level” [*ibid* p20]. Before the final decision was to be taken, the Agroecological Studies Unit and other experts were to “undertake a study to determine what CIAT’s role should be in an ecosystem-focused approach to agricultural development; on which ecosystem(s) it should focus; and whether a new program should be created to deal with sustainability issues” [*ibid* p21]. Dr Laing saw this proposal as being a revival of the decade-old plan for a Land Research Division but “in a much clearer and more erudite form so that donors could follow it — Peter Jones had done a wonderful job”. However, since this proposal is outlined in isolated sentences near the ends of paragraphs that begin by discussing other topics, and is not given so much as a paragraph to itself, one may question whether it was noticed by donors and Board members. At least a repeat of the 1980 *debacle* was averted.

Preparation of the 1991 Plan

Following the departure of Dr Nickel and his replacement by Dr Nores, the planning process began again. This imposed considerable costs upon the Centre, in terms of both the uncertainty felt throughout CIAT and the time and effort diverted away from research. As Dr Laing explained, “we then went back into the planning mode and lost [what felt like] another 3 or 4 years fooling around, from Feb 1990 onwards, and the net result was that CIAT became further and further debilitated while the very planning process was continuing.” The eventual result was the 1991 Strategic Plan [CIAT 1991], which proposed the creation of a new Division of Natural Resource Management which would house three new Ecosystem Programmes, while the existing four Commodity Programmes would now

comprise a Germplasm Division (see diagram below). The new Plan thus combined an enhanced commitment to environmental objectives with the creation of new structures to implement these new objectives.



There were a number of reasons for Dr Nores' decision to reject the Plan that he had inherited and develop a new one instead. As discussed above, CIAT's efforts to undertake environmental research had for long been hampered by the lack of an institutional base for such work. And donors, with their new-found enthusiasm for sustainability, had difficulty believing that a Centre whose organisation was based on Commodity Programmes could be carrying out this kind of work. As Dr Laing explained:

The donors didn't understand, we had to tell them repeatedly, that we were doing more than just breeding. But convincing people [of this] when we didn't have a structure for it was difficult. Some Centres, CIMMYT for example, were not doing any environmental research within their Commodity Programmes, so it was very difficult to convince particular donors that [we were different]. They were apparently not convinced that we were doing it since we didn't have environmental Programmes.

Personal interests also played an important part, both in the decision to reject the 1989 Plan and in determining the character of the new Plan that replaced it. Dr Laing believed that the new DG "wanted to throw away the earlier plan because it was someone else's, so that he

could be seen as the leader of CIAT". For Dr Filemón Torres, then (together with Dr Laing) a director of CIAT, the resumption of the planning process represented an opportunity to advance his own agenda. He wished to see CIAT placing greater emphasis upon environmental research while drastically reducing the attention paid to productivity research. Dr Laing recalled that his outspoken advocacy of this position "infuriated the staff [since] everybody was involved in productivity research" while the research agenda that he expounded throughout the planning process seemed poorly-defined, so that his efforts are unlikely to have contributed to securing acceptance for the new Natural Resource Management Division within the Centre. However, his enthusiasm for environmental research "influenced Nores, who was keen to have a new plan".

Once the decision had been taken to engage with issues of sustainability on an ecosystem basis, it became imperative to choose a limited number of specific environments upon which to concentrate this work. Clearly, there was no question of developing broadly applicable solutions. The process of selecting critical environments was both methodical and time-consuming, and required that strategic decisions be taken at the highest level of the organisation. The outline of the process was defined by the Director General's first decision, as Dr Jones recalled:

The then DG [Dr Nores] was quite adamant that we should forget what CIAT had done before, and identify the problems and opportunities [in resource management], and their location. So we went back to the databases and after about six months we produced an environmental classification of the continent. (We did use our knowledge of CIAT crops to design the classification scheme that we used for the continent.) We came up with 46 different environmental classes into which anywhere with a productivity potential could be placed. We mapped those, we superimposed information on population, rural income, a productivity index, we tried to estimate some sort of indices of sustainability problems, and classified those 46 environments (purely as environments, without taking into account what people were doing with them).

Once the required data on each of the environmental classes had been collated, this information provided the sole basis for the choice of agro-ecosystems upon which to concentrate. Again, this decision was made by senior management, assisted by a series of expert committees:

What I liked about the process was that it was all done blind: we would sit here producing the classifications or tables of results, and I would then take them into a meeting of the Management committee or an expert committee of the various scientists, and they would judge the indices (without knowing which regions they referred to) and pick out the important classes. ... The committee — a dozen or more people — went through a process of scoring these, and we came out with three prime areas of interest for CIAT. Near the end of this process, I revealed that these three environments were

the acid well-watered hillsides, the savannahs, and the forest margins. We had spent a year documenting that these were the most important agro-ecosystems on which to work.

Then we started writing our Strategic Plan. We planned to have an Ecosystem Programme for each of those areas, and a Land Use Programme to study basic land use issues [common to all three agro-ecosystems], to extrapolate results from study areas back on to the totality of the ecosystem and to monitor progress and results.

This analysis led to the decision to found Programmes to serve the Hillsides, the Savannahs and the Forest Margins. The Natural Resource Management Division was to be completed by a Land Use Programme, while the existing four Commodity Programmes were to be housed in a Germplasm Division.

The 1991 Strategic Plan

The document that eventually resulted from the above process conveys an overall impression of confusion and inconsistency. Given the range of interests that were represented in the planning committee, as well as the backgrounds of the donors and CGIAR bureaucrats for whom it was written, this result is not surprising. Thus, the Plan states at various points that its central targets are growth, equity and enhancement of the resource base: the possibility of conflict between these goals is not really acknowledged. These goals are to be pursued by means of strategies based on CIAT's cultural values and comparative advantages, although the next passage (still in the introduction) warns that CIAT needs to adapt to changes in the external environment: "traditional research paradigms based largely on productivity considerations must give way to new technology design conceptualisations ... This requires a change from a supply-driven to a demand-driven systems approach." [CIAT 1991, v] The introduction concludes by promising that CIAT will integrate germplasm development with resource management research, but does not say how that integration will be achieved.

The second chapter, entitled 'CIAT in Perspective' considers the Centre's capacity to undertake the tasks that it had set for itself. The problem that it poses is that: "The existing CIAT research paradigm has been based on a supply-driven reductionist approach, concentrating on developing products that would overcome the major production challenges posed by the environment." [*Ibid* pp14-15] It argues that a new approach is required to promote sustainable systems, seen as developing technologies that link a farm's

performance in achieving different kinds of objectives, but CIAT's ability to adopt this is limited by a number of constraints, listed as;

- funding
- "a rather fixed organisational model limits the changes that can be accommodated, and the number of commodities that can be integrated at the systems level"
- CIAT's experience within a commodity research approach "does not provide a strong framework on which to base a systems-oriented research paradigm, geared toward resource management research in important agroecological settings" [*ibid* p15]

This chapter of the Plan concludes by outlining the four 'guiding principles' that were to be followed by CIAT as it implemented this new strategy:

- relevance and goal orientation
- systems perspective: since it was acknowledged that agricultural problems cannot be resolved through uni-dimensional approaches that concentrate only on given elements, the Plan specified that work was to be undertaken "with a clear perspective concerning the physical, biological, socioeconomic, policy and land use dimensions that may impinge on technology options" [*ibid* p16]. In view of the range of disciplines that are relevant to this task, only some of which could be represented within CIAT, this made necessary a
- multi-institutional approach, since "the task at hand is so large that no one institution can claim exclusive responsibility. Thus an integrated, multi-institutional approach is needed not only to pool resources and bring together different perspectives but to share a vision of the problems and challenges at hand, and to be able to arrive at joint research agendas and priorities." [*ibid* p17] And CIAT's role or 'share' of the overall research agenda would be allocated on the basis of its
- comparative advantage.

The following chapter of the Plan includes a Strategy Statement, which explains the basis for choosing the agroecosystems upon which resource management research would focus and then states that: "The aim of research will be to understand the basic processes within the agroecosystems for the purpose of making agricultural production more sustainable." [*ibid* p21] Since the focus of this research had shifted from crops themselves to the

Ecosystems within which they were grown, CIAT now required organisational units for whom the Ecosystem, rather than the commodity, would be the system of interest.

However, the shift of research interest from commodities to Ecosystems held profound implications for the style of research conducted at CIAT. The focus of research interest was now upon Ecosystems, which are more complex (exhibit greater variety) than discrete commodities. The principle of requisite variety (page 18) suggests, therefore, that the new Ecosystem Programmes needed a corresponding degree of complexity if they were to act upon their target environments in an effective manner. In particular, they needed to incorporate expertise relating to (at least some of) the crops grown in their target Ecosystems, as well as to the human decision-makers whose choices would determine how the environment in question would be managed. Since it would not have been feasible to incorporate specialists in so many areas in each of the new Programmes, they needed instead to have ready access to expertise held in other parts of CIAT, and in other institutions. This was acknowledged by the Strategic Plan, which promised that the Programme-based structure would be “complemented by increased use of ad hoc work teams for specific research problems that must be addressed outside the organizational program structure” [*ibid* p73]. The passage continues:

These ad hoc teams will be composed of staff members from various programs and units, as appropriate, and will be supported with flexible budgets. The organization can be described as following a partial, matrix approach, with programs being the pivotal axle of the organization and selected projects cutting across programs.

The principle of requisite variety thus holds implications for the organisation of Ecosystem-level research. This principle suggests that if such research is to be effective, the ‘human activity system’ responsible needs to incorporate expertise drawn from a range of disciplinary or institutional contexts and including an appreciation of the aspirations of relevant stakeholders. In other words, Ecosystem-level research needs to practice ‘fifth-generation’ innovation. The four ‘guiding principles’ listed above also suggest this conclusion.

Resource Allocation

After making the above decisions about CIAT’s future structure, goals and strategy, the “horrendous replanning process” (as Dr Laing termed it) moved on to questions of resource allocation. “At one stage CIAT was supposed to be fifty-fifty [between Ecosystem and

Commodity work], another, sixty-forty.” Eventually, however, the Director General acted to bring it to a conclusion: “One day late in 1990, after we had been talking for a year or more, Nores said ‘this is what it is going to be’ and he came out of his office with a famous diagram of the percentage of the CIAT staff to be in each of the Programmes, and that was it. It was about sixty-forty [between Ecosystem and Commodity work].” His diagram made it clear that forty per cent of the money that had been spent on crop research would now be diverted to Ecosystem work. Claims were made that new money would be attracted to finance the new activities but “everybody knew by this time that ... there was no more money. Nores knew that the forty per cent was going to come out of the Commodity Programmes, that was clear.”

Since no new resources were forthcoming, establishing the Ecosystem Programmes meant cutting the Commodity Programmes. The Leader of the Bean Programme described the situation in the following terms: “They [the resource management Programmes] did not get much money — that was the problem. If they had got their own money that would have been fine, but they didn’t get it so they had to take ours.” A leading member of the Lowlands Programme recalled that “a lot of people reacted negatively to this: it was a decision imposed from the top, all of a sudden we are going to have a spanking new division and it will take so much in funds away from the commodities, and this put people’s backs up”. Dr Laing, then the director responsible for crop research, “was completely opposed to the first cuts that Nores made”. In this highly-charged atmosphere his opposition to the cuts meant that he was “branded as being opposed to the idea of environmental research”, even though “I had been fighting for it for years, but not to destroy what had been extremely productive in the Commodity Programmes”. His inability to protect the budgets of the Commodity Programmes was the reason for his resignation from CIAT at the end of 1991. Resentment at these cuts, together with negative reactions to Dr Filemón Torres’ comments on productivity research and the perceived lack of definition of his plans for environmental research, all acted to inhibit the cooperation between the two Divisions that was necessary to implement the new strategy.

Some Difficulties with the new Strategy

The Strategic Plan had promised that CIAT would integrate germplasm development with resource management research: this was seen as one way in which the Centre would place “increased emphasis on the context, or system, in which agricultural development occurs” [*ibid* p59]. The formation of *ad hoc* teams drawn from various Programmes in order to address multi-dimensional problems was one of the ways in which this integration was to be achieved. Such teams would constitute ‘research systems’ possessing, it was hoped, sufficient variety to match the complexity of the system under investigation. However, these plans for integration faced formidable obstacles. The transfer of resources away from the Commodity Programmes, together with the unfortunate rhetoric employed by certain advocates of the shift to environmental research, had damaged human relationships between the members of the two Divisions and thus made it difficult for effective cross-Programme teams to be formed. Nor did the Ecosystem Programmes serve those environments in which most CIAT commodities are grown. This problem was compounded by a number of organisational difficulties, including the absence of any definite integrative mechanisms.

A Commodity Programme Leader explained the manner in which the two-division structure was expected to integrate germplasm development with resource management research:

The original conception was that CIAT would have a germplasm division and a resource management division. The germplasm division would supply adapted germplasm to the ecosystem programmes and they would then join together. They would use it, there would be some feedback, and they would work together in these environments. That conception, which is still present, depended on the demand for germplasm from the ecosystem Programmes. In practice, the ecosystem Programmes vary in their capacity to make demands upon us.

Despite the apparent logic of this procedure, implementing these plans may have been unnecessarily difficult. The Leader of the Cassava Programme criticised the choice of critical environments (and by implication the method by which the choice was made) for not matching the ecosystems where most CIAT commodities are grown. As a result, the Ecosystem Programmes need to consider crops that lie outside CIAT’s mandate but are important within their regions, while the Commodity Programmes are not supported in

their efforts to investigate Natural Resource Management issues around their respective crops:⁴⁷

Look at the Rice Programme: a long history of working with irrigated rice, but none of the ecosystem Programmes contemplated working in irrigated ricelands. Or the Cassava and Bean Programmes: long history of working in sub-humid and dry areas, rain-fed and susceptible to drought, but regions like this were not considered as objects of ecosystem Programmes, so the natural overlap just did not occur.

In particular, he felt that his own Programme would have benefited from the support of an Ecosystem Programme working in the same kind of environment. "We do need the input of the ecosystem programmes in our integrated projects, which are located where we have good institutional arrangements, mainly in sub-humid or semi-humid ecosystems." But none of the Resource Management Programmes were mandated to work within these ecosystems, despite what he termed "a battle with the Administration."

He explained that resource management had become increasingly important as part of the natural evolution of the cassava integrated projects. "What our integrated projects have managed to do is take the first steps towards generating income ... but that income in turn needs to be re-invested in even better income-generating opportunities, or at least in activities that provide the possibility of maintaining the resource base." And the assistance of an Ecosystem Programme would have been particularly valuable in identifying opportunities to re-invest income in activities that maintain the resource base.

The manner in which the critical ecosystems had been selected may, in fact, mean that integration between the two divisions would not be appropriate. One of the Programme Leaders stressed that this integration "would have occurred much more easily if they had first found out where beans or cassava had grown and had worked there. [Instead] the approach that was taken was not to use CIAT crops to decide where we should work." From this decision, it followed that the ecosystem Programmes needed "time to mature and to define the real problems [in the environments that they serve. And then the solutions they require] may not be cassava, beans or tropical forages." Only once these Programmes had defined the commodities that they needed could their work be integrated with that of the Commodity Programmes, and then only if they found that CIAT crops were priorities in

⁴⁷ He did concede that the Lowlands and Forages Programmes complemented each other, since the Lowlands concentrated upon serving the savannahs, where forages are the main crop grown. These two Programmes had been formed by dividing the pre-1991 Pastures Programme.

their environments. However, he observed that “there has been an awful desire that all this integration should happen just like that. I think that even the Board of trustees was over-anxious that there should be this integration, where in fact it may not be required. Maybe there was over-anxiety to ensure this overlap, when the process had to run for a while to see whether it was going to or not.”

Additional organisational problems, that further increased the difficulty of integrating the work of the two Divisions, were discussed by a Programme Leader: “The problem of how the two divisions met was not really considered ... no definite integrating mechanisms were put in place.” He argued that this lack of integrating mechanisms was compounded by another management decision: “as we moved into this two division structure (which has now been taken away) they took away all the agronomists from the Commodity Programmes.” This reduced the possibilities of interaction by removing “the link to identify relevant resources to offer to the ecosystem programmes.” Another senior scientist interviewed had seen this transfer of agronomists as a minor matter — “a few re-positionings” — indicating at best a failure of communication. But for this Programme Leader “the point where the two Programmes meet is the agronomic adaptation of these specific commodities in ecosystems. To be able to achieve this integration, you really need an agronomist.” There are, then, considerable constraints to achieving the promised integration between the work of the two divisions.

Another difficulty was that implementation of the Strategic Plan coincided with a severe reduction in the Centre’s income. As another former Programme Leader (Peter Jones) explained, after completing the Strategic Plan:

we tried to do it by the textbook, and we started writing an operational plan. And that is what caught us in a downward spiral, because by the time we had finished the operational plan our budget had been reduced, so we would go through another round of re-writing the plan, and we were getting into the stage where we were writing ourselves out completely, because every time we re-planned something, by the time we had re-planned it we came out with less money. I think that that has worked against us, because now people will ask what we have done in the last three years, and the answer is that we have written plans. ... In 1990 or 1991, when we had the Strategic Plan, if we had taken the very bold plunge of doing something, rather than making further plans, we would now be in a stronger situation. ... [But] now we are into the stage where what we are doing is writing project proposals: nobody is actually doing anything. We need to break that cycle and actually get some work done, then the money will start coming in, but it has been very difficult. Everybody is up to their eyes in writing reports and plans. After we finish this external review we’ve got another one on resource management for June.

The acute frustration felt throughout the Centre, as research was suspended to make way for this endless planning process, was to become an important factor in future developments.

Response of the Commodity Programmes

The Commodity Programmes were severely affected by the Centre's change of strategy. At a time when the total resource available to the Centre was declining, nearly half of that resource was to be taken away from them and instead spent on the new Resource Management division. The Leaders of the Commodity Programmes responded, not by criticising the concept of resource management research, but by arguing vigorously for an approach similar to that enshrined in the 1989 Strategic Plan. Their view was that environmental research should be focused upon the crop, rather than the ecosystem, and should concentrate upon the development of sustainable systems for cultivating 'their' crop. This sort of research, naturally, would belong within the existing Programmes rather than in new structures, so the competition for financial resources would become unnecessary. Thus, the Leader of the Bean Programme argued for:

very strong commodity work that can be used to promote the different theories, practices and prototypes that come out of natural resource work. It has got to come down to a focus somewhere, and in the end the whole focus has to be better crop productivity. In the end it has to be shown to be making crops more productive in a more sustainable way, so that a higher yield is sustained through better management of the environment.

In support of these arguments, they emphasised the environmental aspects of their Programmes' current work while developing a portfolio of projects that would demonstrate the benefits of supporting the approach that they advocated. On the whole, these projects concerned cropping systems based on the host Programme's 'own' commodity, and were characterised by the emphasis that they placed upon productivity gains, seen as necessary in order to motivate farmers to adopt more sustainable cultivation practices.⁴⁸ Underlying such project designs were some fairly simplistic assumptions about farmer decision making, assumptions that in some cases were refuted by the experience of the projects in question.

⁴⁸ Thus, the Leader of the Bean Programme commented that: "Farmers are not going to adopt resource management technologies unless you have improved varieties. If they are still stuck with the same traditional varieties then there is very little incentive for change ... [but] if they see an improvement [in productivity] then they may be willing to adopt longer-term management practices"

This approach did, however, prove attractive to donors: the Bean, Cassava and Rice Programmes were all reasonably successful in attracting external support for projects of this type. As the Leader of the Bean Programme commented:

We have found new funding opportunities in the area of resource management, and we have gone for those. Sometimes we had to push our donors into [this area] because they looked upon the Bean Programme as being primarily a germplasm improvement programme, and it was not obvious to them that we also had a real advantage in doing natural resource management work. Now they have seen that advantage ... so we have become rivals of the Ecosystem Programmes at CIAT.

In particular, the cassava Programme succeeded in attracting support from Germany, so that its Crop-Soil Management project was managed by an employee of the University of Hohenheim. The character of this project changed following CIAT's adoption of the 1991 Strategic Plan, which had stressed the importance of research collaboration with external bodies. Earlier, it had essentially involved on-station research on the mechanics of soil erosion under different cassava-based cropping systems. Now, however, a range of on-farm trials were jointly conducted with various public bodies, non-governmental organisations and community-level associations. The technologies now being tested and demonstrated were, on the whole, different kinds of 'living erosion barrier': plant species that could be grown together with cassava to protect the soil from the degradation likely to occur under cassava mono-cropping. Considerable efforts were made to identify plant species that were not only effective as 'living barriers' but also contributed to short-term farm income. Such a contribution was seen as essential if farmers were to devote land and labour to the plant in question. These efforts extended to organising cooperatives and effecting other local-level institutional changes in order to make it possible for products of the 'living barriers' to be sold.

The Commodity Programmes, then, responded in an essentially political manner to the shift of resources away from them to finance environmental research. By implementing a portfolio of projects that addressed environmental concerns, yet were focused upon a particular commodity and therefore fell within their own area of expertise, they sought to demonstrate that they were the most appropriate agents to undertake environmental research. These projects also enabled them to compete effectively with the Ecosystem Programmes in the contest for external resources. Of course, the attention that they

devoted to these projects served to reduce their interest in collaboration with the Ecosystem Programmes.

From Upland Rice to Prototype Systems: the rice pasture rotation

The development of rice-pasture rotations was an experience that was to prove seminal for much of CIAT's later work in the management of natural resources. In particular, it was to exert a powerful influence upon the definition and development of the Inter-Programme project (to be considered in detail in Chapter 5). This was the first project undertaken by the Centre that involved collaboration between different Programmes. It depended upon contributions from the Rice and Pastures Programmes; the latter became (after the reorganisations of the early 1990s) the Forages and Savannahs (later Tropical Lowlands) Programmes.

Since the 'research system' responsible for this project was able to draw upon expertise housed in three different Programmes, it exhibited greater variety than did any individual Programme. I shall argue, however, that the lack of social science contributions for much of the duration of the project meant that the variety of the 'research system' did not match that of the system under investigation. This lack of 'requisite variety' meant that critical dimensions of the problem were not recognised by the research team and were therefore not taken into account in the formulation of the solution that was developed.

Despite these reservations, the success of this project (at least in technical terms) meant that it was seen within CIAT as an exemplar, both for inter-Programme collaboration and for research on natural resource management. The concept of *prototype systems*, around which the contributions of the three Programmes were integrated, was thus established within CIAT's professional culture.

Acid-tolerant Rice

The starting point was the observation that upland rice was being grown in parts of the Brazilian savannahs, where lime was used to neutralise the acidity of the soil (which would otherwise have killed the rice plants). This rice was being used to restore the fertility of old pastures and to open up new ones. However, the use of lime would not have been practi-

cal in similar environments elsewhere in the region (for example in Bolivia) which would otherwise have been suitable for upland rice. As the rice breeder responsible later recalled, he and his colleagues saw that if they could develop an acid-tolerant rice variety then this practice could spread from Brazil to other areas with similar conditions, areas where “land like this was being used very inefficiently. [We saw that we had] an opportunity to contribute by developing lines to make the diffusion of this practice possible to regions where the same situation was present as had been in Brazil twenty years earlier.” The objective of this work “was not just to grow rice in the savannahs but to improve the efficiency [of land use] in that area. These areas are used for cattle ranches [and] the ranchers are not going to become rice farmers, since their main objective is to raise cattle. [So] we tried to adapt these rice lines to grow well together with the pastures.”

The rationale for this approach was outlined by a leading member of the Lowlands Programme, who explained that at the end of the 1980s it was realised that a mixed system was a better option for the savannahs than pure pasture, since pure monocropping was not going to be sustainable. “Degradation was already occurring in a few pastures and soils were losing their fertility under a monoculture of forage crops. So the idea came to mix [crops and pastures] in an agro-pastoral system. ... The Leaders of the Rice and Pasture Programmes then decided to put these together into a system, where the crop and pasture phases are rotated. We knew that pastures [that included a legume component] could improve the soil ... but *there has been great difficulty in getting legumes adopted* in the savannahs. So *this was one idea to encourage adoption.*” [Emphases added]

These ideas are restated and developed by Dr Raúl Vera, then Leader of the Savannahs Programme, in his contribution to CIAT [1993a, p12]. “In developing new technology for the savannas, our working hypothesis is that integrated crop-pasture systems are more productive and sustainable — mainly because they use resources more efficiently — than continuous cropping or pastures alone. The products of this research are ‘best bet’ prototype agropastoral systems, which local institutions and farmers can readily adapt to specific circumstances.” For this reason, the project began as a collaborative venture between the Rice and Pastures Programmes. As the rice breeder recalled: “From the beginning of the project we worked together ... until we proved that the idea would work.”

The task that they faced was daunting, since at that time nobody knew whether the development of acid-tolerant rice varieties was possible. Indeed, what was necessary was to combine tolerance to soil acidity and to low levels of nutrients with high grain quality (essential if the rice was ever to be sold). The first crosses were made in 1984, and the first material was released in 1991/2. This material had all the traits that had been pursued, although the grain quality, while good (better than the original materials from Brazil), was not of the very highest. The Programme had thus spent eight years proving that it was possible to develop such materials.

The Rice-Pasture System

As soon as this acid-tolerant rice variety had been developed, a post-doctoral research fellow was employed to develop a system that would use this variety at the level of the farmers. Dr JI ('Nacho') Sanz, who was entrusted with this responsibility, was later to manage the Hillside Programme's research project on the development of prototype systems (see Chapter 5 below); as he confirmed, this experience in the savannahs helped to shape his approach to this later task. His work in the savannahs, as Vera [in *ibid* p12] explained, was the development of the rice-pasture system, in which growers "simultaneously sow forage grasses and legumes with rice. The legume improves the nutritional quality of the forage, resulting in higher livestock production. It also reduces the need for nitrogen fertiliser." Many of these forage legumes, added Dr Brigitte Maass (then a Germplasm Specialist with the Tropical Forages Programme) [in *ibid*, p8] "have tremendous potential for improving the soil, raising forage quality, and delivering nitrogen to companion grasses. Some of them also make terrific ground covers in cropping systems."

Despite these benefits of planting forage legumes together with grasses, ranchers had been reluctant to do so (as noted above). This behaviour was partially explained by a former member of the Savannahs Programme: "if you include legumes you need a financial surplus to do that [to cover the initial costs]. You need to give certain legumes a start-up fertiliser, you need to prepare the soil for the legume so you need ploughing equipment, while the areas are so big that you cannot do it manually." Hence, as Vera [in *ibid*, p12] explained, the importance of the rice crop within this system is that it "offers farmers a source of cash income, which covers the costs of establishing the system. Because the grass-legume pasture uses some of the small amount of fertilizer applied to rice, it's ready for grazing

within four or five months — by the time rice is harvested — or less than half the time with pastures alone. Quicker establishment of a ground cover reduces erosion and leaching of nutrients.”

The Lowlands Scientist quoted above stressed that these developments “were driven by the technology development”, which took place during “a long gap without a socio-economic position in the Pasture/Savannahs Programme”. Once this gap had eventually been filled, the socio-economic work that was then performed revealed that “the system in the Colombian *llanos* is driven by speculation over land prices”, which explained why the demand for acid-tolerant crop lines was “not yet great: ... there is a sort of demand from farmers for further crops and further systems, although they are still not very keen”. However, this socio-economic work also “suggests that we will have opportunities for looking at the adoption of technology in the areas where land prices have stopped increasing so dramatically, where farmers can no longer cover their costs by buying and selling land but have to intensify the system in order to make money. This means that things like the introduction of grass-legume crops begin to make sense to them.”

However, another fundamental difficulty was revealed by this belated socio-economic research, together with the Lowlands Programme’s recent experience of on-farm work. This was the fact that in this region “the farmers have no experience of legumes and don’t know how to manage grass legume pastures. ... [This means that] the use of nitrogenous fertiliser might be a better option in pure grass pastures, rather than struggling to introduce legumes into the system ... It is a lot easier for them to handle a fertiliser. So now we are looking at that option, mainly because the farmers see it as much more manageable, an option that fits in with their own socio-economic background.” Exploring this “better option” represented a considerable departure for the Lowlands team, which “had always been working in low-input systems” and for whom “it was a bit taboo to talk about nitrogenous fertiliser”. The wishes of the Programme’s donors posed a considerable dilemma, since they wished to see both work on low-input systems and greater responsiveness to farmers, but probably did not realise that these farmers “almost certainly don’t want low inputs, because they know that low inputs mean limited outputs”.

The development of rice-pasture systems may thus be seen as an attempt to package together two technical solutions — acid-tolerant rice and forage legumes in pastures — that had been developed without the benefit of socio-economic research and so were predicated upon some fairly simplistic assumptions about the determinants of rancher decision-making. The objective of this ‘packaging’ was to make these technologies more attractive to ranchers in the savannahs; the strategy pursued was the development of ‘prototype systems’.

Prototype Systems

Within the Lowlands Programme, as one of its leading members explained, the project to develop ‘prototype systems’ aims to design systems that “will be good for the land and also good (profitable) for the farmer”. The need for socio-economic work to verify that the systems developed were indeed “good for the farmer” — that is, that they met farmer goals — was a lesson learnt at a relatively late stage. “Then, once it has been developed and tested, the time is ripe to tell farmers about the system so that it can be adopted.” This project thus “comes up with best-bet options, mainly in terms of components of systems”. So this work involves identifying components that not only might be profitable for the farmer but also might renovate the land, and examining interactions between the components as well as the performance of each one. These systems are developed as combinations of pastures and crops with green manures, combinations that are better options than current practice “and certainly the biophysical evidence suggests this [although] the socio-economic evidence is not so clear yet”. While some of these combinations are mixed pastures (sown with a crop) they are mainly developed as *rotations*: the different crops are planted on the same land at different times, so the variation is in time rather than in space.

Another scientist, a former member of the Savannahs Programme, explained that the range of crops and the general range of activities is limited, while the focus is upon pasture-based systems. And since the savannahs are flat and essentially constitute a single environment, only a limited role is envisaged for the farmers in adapting these systems to fit their particular requirements: “the environment is quite homogenous [so] ... in many cases the farmer’s field will be very similar to our plots ... [especially since] the farmer will be able to use techniques comparable with those that we use”.

Within CIAT, the way in which this work was organised changed as the project itself evolved. As the rice breeder explained above, its early stages were characterised by close collaboration between all the scientists involved, but once the rice-pasture system had been developed this effort became fragmented in response to the nature of the remaining problems: "I think that now you see more separation than in the past, because now everyone is trying to work on different aspects of the problem. ... Now we are working on the details, and these require much more specific activities. ... It is very hard to put all of this together. We only put together the results that work, which we incorporate into the system. ... There is a very close relationship between the Rice and Savannahs/Tropical Lowlands Programmes, we get together and exchange information, but the work is more independent than it was four years ago. [This project] is much bigger than it was, so it is much more difficult to see everything. But every time something new comes, it comes right into the system straight away."

This work, then, was led by the development of technical solutions to problems that were apparent to scientists. Their response to these problems drew upon expertise housed in different parts of CIAT and so initially involved the development of new ways of organising their work. At a later stage of the work, when attention shifted from the design of the complete system to the performance of its components, the researchers reverted to more traditional forms of organisation.

The problems addressed by this effort had been defined by scientists and solutions were developed with little or no input from farmers, while the role allowed for social research was also extremely limited. Thus, although the research succeeded in developing a system that exhibited desirable emergent properties (rapid pay-back of initial investment, longer-term sustainability and profitability), use of this system was limited by farmer characteristics that had been unknown to the researchers. However, the technical excellence of the system and the importance of the sustainability issues that it addressed meant that once its effectiveness had been demonstrated, donors were keen to support this work. And within CIAT this experience is widely seen as an exemplar, both for inter-Programme collaboration and for research on the management of natural resources.

The experience of this project was therefore to exert a strong influence upon the hillsides inter-Programme project. Once the Centre's Board had decided that biophysical and other scientists from various parts of CIAT were to be made available to the Hillsides Programme for a collaborative resource management project, the scientists who were to take part in the new project were chosen because of their previous involvement in the rice-pasture work. Dr Sanz, who had 'put together' the rice-pasture system, was thus chosen to manage the new project. Nor was this all: since the concept of 'prototype systems' had provided an effective organising principle for the rice-pasture work, those involved in planning the Hillsides inter-Programme project immediately assumed that their task was to develop prototype systems for the (radically different) hillside ecosystem. This assumption defined the framework within which the new project was planned, and thus fixed the direction of the project itself.

Implementation of the new Strategy

Earlier, before the first strains of acid-tolerant rice were ready for release, CIAT's prolonged period of planning had concluded with the adoption of the 1991 Strategic Plan. This document had set out an expanded set of objectives that the Centre would pursue (concerned not only with increasing the output of agriculture but also with its environmental impact), and had specified the research approaches and guiding principles that were to shape the Centre's work. It had gone on to specify the structural changes that were believed necessary for the new set of objectives to be pursued effectively, changes that included founding four Ecosystem Programmes to complement the existing Commodity Programmes. Indeed, the Plan had listed the numbers of people in each skill area who were to be appointed to the new Ecosystem Programmes, so finding and appointing these people was the first task necessary in order to create the new Programmes. The remainder of this chapter will examine the way in which this task was accomplished.

The formation of the Savannahs Programme was easy, since the then Pastures Programme had a long record of working in this ecosystem. This Programme included breeders (of forage crops), soil scientists, nutrient cycling specialists and ecophysiologists, so all that was necessary was to divide it into the new Forages and Savannahs Programmes. As a result, the Savannahs Programme inherited skills that already existed at CIAT. Indeed, to

some extent it had been designed to use skills that CIAT already possessed, enabling the Centre to build upon its comparative advantage.

For the Forest Margins Programme, a Leader was recruited from outside the Centre and given the task of forming her team. At this point, however, CIAT suffered a financial crisis and all recruitment was frozen. The Leader of this Programme was never allowed to recruit the staff that she needed, and left after two years. Ultimately, the work in the forest margins ecosystem was added to the work-load of the Savannahs Programme, which was then renamed the Tropical Lowlands Programme. This financial crisis also meant that the Land Use Programme, which had been formed from the Agroecological Studies Unit, was now converted into the Land Management Unit, although the implications of this change are not clear. (This Unit has been more successful than most other parts of CIAT at securing external finance.)

The formation of the Hillsides Programme (Laderas) began with the appointment of Dr JA Ashby as its Leader. As another member of Laderas explained, her work running the IPRA Project had been undertaken in this ecosystem, so on her appointment "she brought her participatory research ... [and] all the work that she had been doing ... with her". She also brought a great deal of expertise in socio-economic research, embodied in the people who had worked with her on the IPRA Project, but none of these were qualified at PhD level. "Then she had to look for soil scientists, agronomists, organic matter specialists, and so forth" to fill the positions listed in the Strategic Plan. She only had time to recruit one scientist from outside CIAT, an urgently-needed Soils/Systems Specialist, before all recruitment was frozen in response to the financial crisis. While scientists with the necessary skills, and with experience of working in the hillsides ecosystem, were employed within CIAT, they were still members of the Bean and Cassava Programmes. With one exception, therefore, they were not available to join the new Hillsides Programme:⁴⁹ taking these people away from existing Programmes would have been politically unacceptable.

⁴⁹The exception was an agronomist employed by the Cassava Programme. Since, as discussed above, the Cassava Programme was losing its agronomists, this person was "in an awkward transitional situation" and so became the first scientist to be recruited by Dr Ashby.

The result of this situation was that Laderas was far less generously staffed than the other surviving Programmes: a report to a major donor [CIAT, 1995] listed ten people qualified at doctoral level employed by the Lowlands Programme, but only two in Laderas (in addition to the Leaders of both Programmes). Since both the Strategic and Operational Plans for the Hillside Programme called for 'hard' science specialists, the lack of these people seriously limited the progress that was possible. At the same time, however, the Programme's resources in socio-economic research were deployed effectively to advance the simulation modelling and community organising components of Laderas' research agenda.

A Solution: sharing Staff

As time passed, it became increasingly apparent that the Centre was not going to be able to attract sufficient donations to enable it to recruit new people to fill the 'frozen' positions. Eventually, in December 1993, the Board decided that scientists with the relevant skills should devote part of their time to assisting Programmes other than their own. A former member of the Savannahs Programme recalled that when this decision was implemented, in mid-1994, "it was decided that Hillside and Forest Margins needed soils people while Savannahs had these people, so let's just make these people work everywhere. And we just got a message from upstairs (via our Leader) that we were to work for so many per cent of our time in each place ... almost everyone in my Programme had to work for part of the time in the Hillside Programme (15-30 per cent of their time) and in the Forest Margins of Brazil (typically for 15-20 per cent of their time) as well. This meant that most of us had three sites in which to work."

The practical difficulties posed by this change were considerable. In principle, one could argue that exposing these scientists to three distinct environments would give them a broader perspective on how resources are managed by the different farmers there, and that this broader perspective would ultimately lead to more rapid progress. (This point was made explicitly by the Leader of the Bean Programme, who argued that the global mandate of her Programme facilitated the transfer of valuable insights between widely separated regions of the world.) In practice, however, a former member of the Savannahs Programme felt that being told to work in three different Ecosystems was "nonsense,

particularly if one site is in Brazil. [Airline connections between Cali and the Brazilian site at Rio Branco are such that the journey takes 3-4 days.] If you have to work for five or ten per cent of your time in Brazil that is nonsense, that is one holiday trip, no more.” He commented that the decision had been made “just from a management point of view, without any feeling for what was really going on” and that “there had not been any discussion with us as to whether or not it was reasonable”. The result, he felt, was that “it didn’t work out: nobody did what they were expected to do. I can’t even remember now whether I was supposed to contribute to the Forest Margins: I just laughed at it. ... I was supposedly in all three Programmes, but we dropped the Forest Margins work immediately because of the distance.”

Thus, while there were good scientific reasons for forming cross-Programme teams to address the multi-dimensional questions arising from CIAT’s new research agenda, the decision that staff should be shared between Programmes actually resulted from a financial imperative. This decision was communicated as an order to the staff involved: their agreement was not secured, nor was any consideration apparently given to the practical difficulties they would face in obeying it. Since this occurred in the context of a re-allocation of resources from Commodity to Ecosystem Programmes, which fomented conflict between the members of the two Divisions, it is scarcely remarkable that the formation of harmonious cross-Programme teams proved problematic.

Conclusions

This chapter has reviewed the history of CIAT, one component of the CG System. It has argued that CIAT, throughout its history, has been held in tension between the norms of the CG System and the imperative to fulfil the eco-regional mandate given to it on its foundation. This tension may be regarded as an example of the contradiction between the 'pipeline' and 'fifth generation' models of innovation.

Over the course of the 1980s the realisation grew, both within the Centre and among its donors, that addressing the most pressing problems faced by the region that CIAT served required a departure from the 'Green Revolution' focus upon isolated commodities. Instead, it was seen as necessary to pay greater attention to the environmental impact of agriculture and to the sustainable management of natural resources. In order to provide an appropriate framework for these endeavours, the Centre embarked upon a protracted period of planning, which concluded with its adoption of the 1991 Strategic Plan. This Plan stipulated that *all* of CIAT's research should follow the research approaches and guiding principles that it had derived from analysis of the conditions necessary for effective resource-management research. It had gone on to specify the structural changes that were believed necessary for the new set of objectives to be pursued effectively, changes that included founding four Ecosystem Programmes to complement the existing Commodity Programmes.

Whatever the merits of these proposals, they did not command a consensus within the Centre but were opposed by the Commodity Programmes, whose resources were to be substantially reduced in order to support the new Programmes. They argued that the new Programmes were unnecessary, since resource management research could best be undertaken within a commodity-based framework. To add credibility to these arguments and to demonstrate what could be achieved by addressing sustainability questions with a commodity focus, they developed a range of projects of this type. Some of these projects were discussed briefly in this chapter, and both their achievements and their limitations were noted. In particular, the development of rice-pasture systems was given more detailed consideration because this project was seen within many parts of CIAT as exemplifying natural resource management research: it therefore established a paradigm within which subsequent NRM projects were expected to develop.

The events and experiences considered in this chapter are all important for understanding the detailed discussion of two linked resource-management projects that occupies the remainder of this thesis. Thus, the structural change prescribed by the 1991 Strategic Plan involved the formation of Laderas as an Ecosystem Programme; the subsequent resource constraints and debates over the best approach to NRM research both left Laderas dependent upon collaboration with scientists from other Programmes and coloured the attitudes of these scientists towards Laderas and its projects; while the development of rice-pastures and CIAT's other resource-management work represented a body of experience that strongly influenced the manner in which Laderas' research agenda was implemented. Equally, the limited impact of CIAT's commodity-based resource management projects serves to underline the importance of the move towards 'fifth generation' innovation that the Hillsides research agenda represents.

Chapter 4 Agricultural Research Practice for Environmental Management and Poverty Reduction: the case of CIAT's Hillsides Programme

Introduction

In the two preceding chapters I considered the development of the CG System, and of CIAT, one of its components. I reviewed the manner in which, at both of these levels, the research agenda changed to reflect the increased attention that was being paid to environmental concerns. I argued that if the CG System was to respond effectively to this new environmental agenda then it needed to modify the manner in which it worked in the ways suggested by the 'fifth generation' model of innovation. I then examined the structural changes that followed the decision to pursue the new environmental agenda, noting the degree to which they were consistent with the prescriptions of the 'fifth generation' model. The changes experienced by CIAT included the formation of an Ecosystem Division that was to house four new Programmes. One of these, the Hillsides Programme, was chosen for detailed examination because the plans that it made for its work represented a profound move towards 'fifth generation' innovation. These plans are discussed in this chapter, while their implementation will be examined in the chapter that follows.

By working at this level of detail, I was able to observe the specific manner in which 'fifth generation' ideas affect the design of a research project and thus are put into practice. It was at this level that the contradictions between the requirements of 'fifth generation' practice and the working practices established at CIAT were most acute. These contradictions, and the responses they elicited from the researchers directly affected by them, revealed the organisational forces that tend to maintain CIAT's conformity to the prescriptions of the 'pipeline' model of innovation. My examination of a specific research project thus enabled me to perceive the wide-ranging organisational changes that would be necessary if CIAT were to embrace the 'fifth generation' model.

The remainder of the thesis, then, discusses the research in natural resource management undertaken by CIAT's Hillsides Programme, Laderas.⁵⁰ This work, unlike the resource management research discussed in the previous chapter, was consciously undertaken at the level of the landscape, rather than at that of the plot, farm or ranch. The decision to work at this level led to a research design that contradicted the prescriptions of the 'linear model' and instead appeared to be more consistent with the 'fifth generation' models of innovation associated with Rothwell [1992] and with Gibbons *et al* [1994]. However, CIAT's institutional character (as discussed in the previous two chapters) was predicated upon the 'linear model', so that both the nature of the work performed by Laderas, and the progress that it was able to make, were constrained by the larger institution of which it was a part.

The strategy pursued by Laderas was explained most fully in a project proposal that was submitted to Canada's International Development Research Centre (IDRC) and to the Swiss Development Cooperation (SDC) early in 1993. The overall objective of this project, entitled *Improving Agricultural Sustainability and Livelihoods in the Tropical American Hillsides*, was to improve the livelihood security of hillside farmers in Tropical America. In order to achieve this, the project aimed to build a working model of participatory research and development for sustainable agriculture and thus to develop systems of land management that would sustain and regenerate the natural resource base [CIAT, 1993].⁵¹ Since this work involves the development of a working model, it has the character of action research: CIAT staff are directly involved in effecting 'improvements' within certain geographical areas. At the same time, the design of the project explicitly acknowledges the complexity of the social and biophysical systems in which it seeks to intervene. This complexity gives rise to the trans-disciplinary character of the project, which thus depends upon contributions from several of CIAT's Programmes.

⁵⁰ The Hillsides Programme was generally referred to within CIAT as Laderas (the Spanish word for hillside). For reasons of elegance and economy, this terminology will be used in the remainder of the thesis.

⁵¹ For an explanation of the ways in which Laderas interpreted the phrase 'participatory research and development', see the discussion in chapter 3 (page 114). In interpreting the phrase 'sustainable agriculture', Laderas concentrated on the requirement for sustainability that the natural resources used by agriculture "be managed as one whole" [Röling 1994 p128]. Röling suggests two ways in which this might be achieved, one of which is if "the stakeholders form a platform for integral decision-making" [*ibid*]. (His other suggestion is that some 'expert authority' may be empowered to manage the natural resource.)

After considering this proposal, IDRC agreed to finance the Andean component of the work (performed in the area around the township of Pescador within the watershed of the Río Cabuyal, a tributary of the Río Ovejas, in the Colombian province of Cauca) while work at two sites in Central America is funded by SDC. The Andean component of this project exhibits the following salient features:

- a) since the traditional distinction between Research and Extension has little relevance for the management of natural resources in a heterogeneous environment (such as the hillsides of Tropical America), an important part of this work takes the form of action research. It is argued that this experience will yield knowledge of "strategic principles" which at a later stage may be transferred to National Programmes elsewhere in the region so that the positive aspects of this project may be replicated,
- b) the unit of analysis is a watershed, regarded as being a complete biophysical and socio-economic system. The trans-disciplinary nature of the processes involved in the degradation and possible rehabilitation of this environment has forced CIAT to assemble a trans-disciplinary team to undertake this research. The managerial and organisational problems that have resulted from this, and the action taken in response, provide a major theme for discussion,
- c) At the beginning of the project a number of local and national organisations were already implementing projects concerned with development and environmental management in the watershed chosen by CIAT for this work. To avoid futile competition, CIAT began by catalysing the formation of a consortium to agree and implement a common development plan. This piece of action research therefore involves participating in a consortium implementing a set of related development projects, pursuing the overall objectives of improving both livelihoods and environmental management within the watershed.

The system discussed thus consists of a watershed and a group of agencies working within that watershed, including a trans-disciplinary team of researchers from an International Agricultural Research Centre. This group of agencies has been working to implement a set of projects that use technical change (together with other tools) to promote social development and improved environmental management. This chapter concerns the management of this whole process.

The remainder of this chapter consists of three main sections. The first of these outlines the approach, or set of underlying assumptions, upon which Laderas based its plans.

Fundamental to this approach is the belief that there is a need for natural resources to be managed at the level of the *landscape*, so that attention may be paid to properties that emerge at this scale. The evolution of such properties reflects the actions of all users of the landscape in question and therefore cannot be controlled by any single individual, nor even by any homogenous group of stakeholders. This analysis suggests that, for natural resources to be managed at the scale of the landscape, it is necessary that all of the landscape's users comply with a coherent management plan. The work of Laderas has therefore concentrated upon the development of local-level institutions that are intended to ensure that this condition is satisfied. Such institutions were also seen as being an important mechanism for the users of the landscape to exert demand for the technologies that they required.

The approach of Laderas is a general heuristic, and could be applied to virtually any inhabited landscape. For this reason, it is stated in abstract terms, without discussion of specific environmental problems or other details of any particular context. This general approach then found expression in the plans that Laderas made for working within a specific watershed in the Colombian Andes. These plans are discussed in the subsequent section, which explains that the construction of institutions to promote landscape-scale environmental management was seen as a prerequisite for the development of technology. Two ways in which the characteristics of CIAT (as a wider institution) impinged upon these plans are noted, after which the strategy for developing technology receives detailed consideration. The final section, by way of conclusion, relates the strategy developed by Laderas both to the debate about development as intervention and to the discussion on the management of innovation presented in the first chapter.

The Approach of Laderas: Research on Landscape-scale Natural Resource Management

A General Framework for Landscape Management

The approach followed by Laderas, like that of the other parts of CIAT engaged in resource-management research, appears to be based upon the assumption that degradation of the resource base in the ecosystem that it serves is associated with the actions of humans who live or work within the target ecosystem and thus make use of the resource base that is of concern. From this it follows that changes in the behaviour of these users of the resource base may reduce or even reverse the environmental degradation that is of concern. The task of research, then, is threefold. Firstly, it needs to identify those human actions that contribute to environmental degradation; secondly, to find less destructive ways in which the actors involved could continue to achieve their objectives; thirdly, to find ways of motivating these actors to make such changes in their behaviour. This agenda is consistent with the widely-held belief that “[i]nfluencing human behavior is key to conserving and renewing resources” [Honadle and Cooper, 1989, p1538]. The previous chapter gives a number of examples of research programmes that conform to this model: perhaps the most obvious of these was the development of the rice-pasture system, which is designed to provide ranchers with a financial incentive to rehabilitate degraded pastures while establishing forage legumes within them.

The distinctive characteristic of the Hillsides Programme’s approach is the choice of the *scale* upon which to work. As an internal document [CIAT 1994] makes clear, the work of Laderas is intended to facilitate the management of natural resources at the level of the *landscape*. This work is therefore primarily concerned with properties that are seen at this scale: emergent properties of the entire landscape under examination. Since the evolution of these properties reflects the actions of all users of the landscape in question, this work is concerned with everyone involved in using or managing this shared resource. This concern with all stakeholders is necessary because the properties that are of concern depend upon the management of the entire landscape, so that even a relatively small number of the

landscape's users could prevent any improvement in these properties from occurring if they declined to change their behaviour.⁵²

The risk of such non-compliance is increased by the fact that the benefits of improved resource management are likely to become apparent in the longer term and at the scale of the landscape. Individual stakeholders may therefore have difficulty in analysing the private advantages that would accrue to them and thus deciding whether or not compliance would be worth their while.⁵³ Indeed, some significant individuals or interest-groups may perceive the benefits of improved resource management as being externalities, particularly if these people give higher priority to short-term costs and benefits than to longer-term issues.⁵⁴ A Senior Research Fellow from Laderas noted that "when we go into a community to conduct a diagnosis, they tend to see short-term problems first, and those are their priorities". To some extent, she felt that this was explained by their situation;

"The farmers ... are under considerable pressure to produce enough to survive in the short term. This means that their decision-making tends to be dominated by short-term considerations, while longer-term issues of sustainability are given lower priority."

A general problem, she felt, was that "a lot of the people who go into sustainable agriculture or conservation work are concerned with things that are a lot more global and long-term than the immediate priorities of the farmers". And the changes that such people propose in order to improve management of the landscape may impose real and immediate net costs upon farmers and other stakeholders. In particular, "many conservation practices that require large labour inputs are not feasible, since the priorities for using limited labour are either cash crops or those used for subsistence".

⁵²The emphasis placed upon the behaviour of stakeholders, rather than upon the broader structural features of the problem, is consistent with the approach of Long [1992]. This author observed that different behaviours by local-level actors may lead to different outcomes, even in structurally similar situations; this was the basis of his argument for an actor orientation in social research. Long and his collaborators demonstrated that actor-oriented research may reveal the specific aspects of the situation experienced by each actor that exert a decisive influence upon that actor's behaviour, and thus upon the outcome.

⁵³This is an example of a general economic phenomenon: the unwillingness of private actors to invest scarce resources in the production of public goods, when the private benefits that will result are perceived as being uncertain or inadequate. Such 'market failure' is analysed in several rival branches of economic theory. For a more extreme example, compare this situation with that considered by the behavioural theory of the firm, according to which the managerial firm responds to unavoidable uncertainty about the future by avoiding long-term planning and working only within a short time-horizon. "The behavioural theory postulates that the firm considers only the shortrun and chooses to ignore the long-run consequences of short-run decisions." [Koutsoyiannis 1979 p395]

⁵⁴In more formal terms, this tendency to place a relatively low value upon longer-term benefits will be seen in those, like the rural poor, whose "subjective rates of time preference are high in comparison to social discount rates informed by sustainability considerations" [Greeley 1992, p34].

This problem of non-compliance has traditionally — and unsuccessfully — been approached by means of coercion backed up by state power. For Laderas, however, the key task is to find ways to motivate stakeholders so that they will choose to cooperate with resource management initiatives. This is seen as the only way to achieve lasting changes: in the words of the Senior Research Fellow “your real impact will only come if you can make people realise that their actions have consequences and that they need to think about these”. Motivation for change, then, is to be produced by making stakeholders aware of the effects of their actions upon themselves and others, and of the ways in which they are affected by the acts of others; “I think that if people can see their behaviour as part of a chain of cause and effect, then I think that you will find more acceptance and motivation to continue to comply”. However, one difficulty with this approach is that “the variables involved in the cause-effect relationships are highly complex” so that stakeholders may have difficulty in appreciating the consequences of their actions. In other words; “One of the problems is understanding the concepts within the communities. Once they understand these concepts, they are more likely to comply with the requirements of the project.”

This analysis suggests ways in which a programme of environmental management conducted at the scale of the landscape might be able to motivate stakeholders so that they will choose to comply with its recommendations. These include initiatives in popular ecological education, together with measures (including the construction of appropriate social institutions) that would encourage stakeholders to pay more attention to externalities. At the same time, it is clear that the changes recommended need to be such that all relevant stakeholders will find them acceptable. It follows from this that such proposed changes need to take into account the interests of these stakeholders and the various objectives that they pursue. Since Laderas had inherited particular strengths in participatory research, it was natural that its staff saw applications of such methods to this problem. Thus, the Senior Research Fellow argued that “it is important to find out what farmers believe, and to understand their decision processes as these affect adoption [of resource management practices]. Farmer participation enables one to find out why they decided to do something, their logic behind it, the resources that they command and their priorities with respect to these resources. This information can be used to design ways of motivating them to follow conservation practices.”

The efforts of Laderas to encourage stakeholders to take account of externalities in their decision-making on the use of natural resources are based upon a key insight. This insight is that the different users of any natural resource are inter-dependent, since “[t]he use each [social actor] makes of the natural resource affects the ability of others to satisfy their needs” [Röling 1994 p128]. There is thus a causal connection between the use made of a resource by one group and the ability of other groups to use the same or other resources. Efforts in popular environmental education are likely to raise awareness of these cause-effect relationships, leading to the application of social pressures for change to those stakeholders whose actions adversely affected the interests of others.

In many of these cases, however, the changes required to improve management of the landscape would impose real costs upon those stakeholders expected to make them, while the benefits would be felt by others. There would then be a tendency for these stakeholders to resist such pressures for change, even though conflict with those adversely affected could result. Under these circumstances there is clearly a role for institutional mechanisms capable of resolving such conflicts in a way that deals with this asymmetry between benefits and costs. In other words, these mechanisms would need to ensure that stakeholders who incur net costs as a result of making the required changes be rewarded in some way. And if this process of conflict-resolution is to be sustained indefinitely then the rewards for those stakeholders who make such changes would need to be provided *by those who benefit from these changes*. Since these stakeholders may in turn benefit from changes made by other users of the landscape, a series of negotiations between these different resource-users may lead to a set of compromises that result in widespread adoption of ‘greener’ resource-management practices. If these compromises are to command legitimacy then, in the words of the Senior Research Fellow, “it is very important that the community feels that its members have some say in how these issues are resolved. Ultimately, the community itself needs to acquire these skills in arranging procedures to manage such conflicts.” The task facing Laderas, then, is to find ways of constructing institutions that will operate in this way and provide a framework for fruitful negotiations between different stakeholders over the management of the landscape.

The development of technology for landscape management

The previous section argued that the management of natural resources could be promoted by landscape-scale institutions able to resolve conflicts over the use or abuse of natural resources. Such institutions, by facilitating negotiations between different resource-users, could also make an important contribution to the development of 'greener' technologies. This is because negotiations of this kind may well reveal changes that the various resource-users *would* be willing to make if doing so were technically feasible. Such information is important for efforts to develop alternative, less environmentally destructive, production methods and land management practices: these efforts need to take into account the interests of stakeholders and the various objectives that they pursue.

Technologies whose development is informed by knowledge of the priorities of their (potential) users are likely to represent a reasonable compromise between what these different users want, and what is technically feasible. Reaching such compromises is likely to involve a process of negotiation about the characteristics of the technology between those developing it and representatives of the main interest groups affected. These representatives (who may be social scientists) need to be aware of the factors that determine whether or not a technology will be acceptable to the different sorts of users whose cooperation is required. Such negotiation is an essential part of the process of innovation: as the Senior Research Fellow explained, "if you find out what motivates the person who is using the natural resource, what are his reasons for doing something, then you can begin to negotiate a reasonable agreement ... [but] the decision-making processes are highly complex".

A prerequisite for such negotiation is that the various stakeholders be able to explain their requirements and to negotiate about the technology to be developed. This suggests that the first task to undertake is the development of these capacities to exert demand for new technologies. It is clear that this should take place while the development of technology is still at an early stage; otherwise the technological agenda will already have been set by scientists, making subsequent negotiation meaningless. An additional point is that building this capacity to articulate technological requirements and facilitating the kind of negotiation among resource-users discussed above will institutionalise the capacity to exert effective demand for technology within the community. Finding ways to do this is itself an important research objective, one that is explicitly addressed by the work of Laderas.

The general question addressed, then, is finding ways in which R&D can be 'driven' by the priorities of farming communities [CIAT, 1994 and CIAT, 1994a]. This general question is broken down into the following components:

- ♦ how to find/create institutional mechanisms open to the entire community, and in particular open to its poorest members;
- ♦ how to strengthen community-based capacities to articulate demands for research. This involves building 'grassroots' capacity to analyse the present situation and to specify the goals towards which research should be directed. The difficulty of this task is considerable, since it requires that clients actively identify their needs and formulate demands, rather than simply respond to opportunities offered to them by external researchers. This demands an enhanced level of consciousness and self-confidence;
- ♦ how to enable communities to make decisions using research results as well as local (indigenous) knowledge;
- ♦ how to build capacities within the community to conduct adaptive technology testing on a landscape or multi-farm scale;
- ♦ how to re-organise the interface between farmers and (technological) researchers in order to increase both communication with and accountability to farmers.

In effect, the above component questions enquire about the nature of the processes that lead to the construction of a 'working model' of participatory research and development for sustainable agriculture. In order to answer such questions, it is necessary to observe the processes under consideration. One way, indeed arguably the only way, to observe these processes is to work in a specific location to find ways of achieving the stated objective. The nature of the research questions thus dictated an apparent departure from the quest for broadly applicable solutions that the IARCs had traditionally been mandated to pursue (see pages 63-67). However, as argued below (see page 162), careful analysis of the experience of building a "working experimental model of sustainable agricultural development for the hillsides" [CIAT 1993 section 1.3] would enable the researchers to identify the *generic*

principles that make different institutional mechanisms successful or not. Knowledge of these principles, it was argued, would make it possible to develop methodologies to identify (or construct) mechanisms that will actually work to achieve these objectives.

Ultimately, then, Laderas saw it as vital that the institutions to be developed should facilitate a participatory process in which relevant stakeholders would be actively involved in diagnosing problems, negotiating compromises between conflicting interests, acquiring information to support decision-making, implementing the resulting decisions and — crucially — sharing the benefits from their implementation [Röling, 1994]. Such a process is seen as essential for obtaining compliance from all stakeholders. However, since CIAT is an international Centre mandated to serve the whole of América, the task in hand was not simply to develop institutions with the required characteristics, but to discover general principles for their construction. These principles, it was argued, could then be applied to the establishment of institutions of this kind throughout the region served by CIAT.

The work of Laderas thus rested on the assumption that those aspects of human behaviour associated with environmental degradation could be changed by a process of negotiation between the different actors involved. Such negotiations, it was believed, would lead to a network of mutually advantageous agreements, each of which would, if honoured, lead to an improvement in some aspect of the management of the natural resource base. In addition, it was believed that both the process of negotiation and the consequent web of agreements would enhance the capacity of the rural people involved to articulate their requirements to researchers and thus to negotiate effectively with providers of technology. A kind of community empowerment in the tradition of Paolo Freire is thus seen as following from the practice of an Aristotelian style of politics. The policy intervention required for this process to begin was seen as the provision of widely accessible institutions within which local-level environmental politics could be practised. The remainder of this chapter will consider the specific plans that Laderas constructed upon the above assumptions for their work in the watershed of the Río Cabuyal. The implementation of these plans will be discussed in the following chapter.

Strategy of the Hillsides Programme

The Hillsides Programme (Laderas) originally planned to begin its work by addressing the research question raised earlier, that of finding ways to build institutions to promote landscape-scale environmental management. The essential function envisaged for these institutions was to facilitate negotiation among different land-users and between these people and the suppliers of technology. In effect, the task facing Laderas was to find ways of developing community-based capacities to exert effective demand for resource-conserving new technology. In order to achieve this, Laderas intended to form a community-based Watershed User's Association (since the landscape chosen was a complete watershed), to develop this as a forum for negotiation between different interest-groups about resource management issues and to strengthen its ability to exert effective demand for technology. Only once this had been achieved was it planned to begin developing new technologies, so that this activity could respond to the demand articulated by the users of the watershed. The intention, then, was to build a "working model ... of participatory research and development for sustainable agriculture ..." [CIAT 1993, p1].

An important modification in this work-plan was made at an early stage. CIAT's donors were anxious to support collaborative work, while the Strategic Plan [CIAT 1991] had at several points stressed the importance of working in collaboration with bodies outside CIAT through the development of consortia and strategic alliances. Thus, the Plan discusses Interinstitutional Relationships (p25), stating that "the emerging collaborative model is based more on decentralized execution. ... The expansion of institutional interactions implies that solutions to problems will increasingly depend on the development of consortia and strategic alliances." And the Plan's discussion of Programme Strategies concludes (p59) that two basic shifts in CIAT's approach to technology development underlie this strategic plan. One of these shifts is "increased emphasis on the context, or system, in which agricultural development occurs"; the other is "the realization that integrated solution models require the participation of many actors; this implies that technology generation is a highly participatory endeavor in which interinstitutional coordination and mutual support are as important as the research activities themselves."

These factors meant that Laderas experienced considerable political pressure to form consortia to share its projects, rather than working on its own. Therefore, instead of

working independently with the people of the watershed, Laderas first forged links with the other (external) agencies that were already working to develop the area in question. A pair of workshops organised by Laderas catalysed the formation of CIPASLA (*Consortio interinstitucional para una agricultura sostenible en laderas* or Interinstitutional Consortium for Sustainable Agriculture in the Hillsides), a consortium of these agencies that was formed around a common programme of action and thus built upon a commitment to undertaking shared tasks. The formation of CIPASLA as a strategic alliance and the opportunity that it represents to acquire experience of “interinstitutional coordination and mutual support” thus conformed to the collaborative mode of working outlined in the Plan. Only then, once the consortium had already been formed, did work on organising the Watershed User’s Association begin, and this task was now shared with the other members of CIPASLA. The consequences of this modification, which were profound, will be considered in the next chapter (see pages 179-184).

Strategic Rationale for the Project

The IDRC Research Proposal [CIAT 1993], prepared in the period following the formation of CIPASLA, provides a comprehensive exposition, both of the strategy pursued by Laderas and of its underlying rationale. The argument that it presents begins by observing that the problems of hillside degradation are well-known, then affirms that in response new “systems of land use, based on integrated technological, organizational and policy interventions need to be developed for the hillsides” [*ibid* section 1.3]. It notes, however, that the design of such systems will involve analysis of the trade-offs between production and conservation, and that within a *diverse* agro-ecosystem such as the hillsides, the results of such analysis will be *location-specific*. There can be no question, then, of strategic research developing a ‘definitive’ system for the entire ecosystem; instead “[t]he essential task is to develop a strategic understanding of *how* to intervene in a hillside agro-ecosystem to establish ecologically sound and economically viable systems” [*ibid* section 1.3]. In order to develop such a strategic understanding, however, it is necessary to identify the key variables responsible for success or failure and to determine their significance. The argument therefore concludes that field-based action research is required, from which empirical estimates of the relationships between these variables may be derived: “A

working experimental model of sustainable agricultural development for the hillsides must be built" [*ibid* section 1.3].

This description of the project as an experimental model is repeated at several points in the IDRC Proposal. Thus, in the section on *Anticipated Results* [*ibid* section 1.4] we learn that it "will develop a model of community-based, participatory R&D ... [which will] develop new systems of land use for the hillsides, based on integrating technological, organizational and policy interventions". As the next sentence in the proposal makes clear, the object of the project is not primarily to improve the situation in the project site but the development of a methodology for innovating in agriculture in a sustainable way. This is intended to contribute to the formation of 'a strategic understanding of *how* to intervene in a hillside agro-ecosystem': "The project will identify principles for making the model self-sustaining; and for replicating it in similar ecological and institutional environments through training." The authors of the IDRC Proposal thus demonstrated the strategic significance of their project, and argued successfully that it lay within the mandate of a CG Centre, even though it closely resembled a piece of location-specific action research.

Strategy for Technology Generation

The strategy for developing technology described in the IDRC proposal depended upon the institutional arrangements that were to be formed around a functioning Watershed Users' Association. As discussed above, this Association was expected to articulate demand for new technology; in practice this meant reaching a consensus on the problems that were priorities for investigation. The Association was also expected to take part in the evaluation of the technologies offered in response to these problems, and to produce a community experimental plan for further trials of these technologies. These latter trials were also to be monitored by researchers, while their outcomes, as evaluated by the community, would inform the development of future technologies. The trials that were involved, together with the institutions around them, would thus have provided a framework within which a constructive dialogue between researchers and land users could have taken place.

However, it was clear that a considerable effort in building community organisation and in popular education, in order to create the capacity to exert demand for new technology, was a precondition for the success of this strategy. And since the technologies to be

developed would depend upon the problems selected by the Association, it was not possible for the proposal to specify them in any detail. Instead, it described the process by which technological research goals would be first set and then revised.

At a number of points, the IDRC Proposal explicitly acknowledges the dependence of this strategy upon the institutions to be set up. In the first place, the proposal specifies that CIPASLA (the Watershed Steering Committee) should begin the process of technology generation by co-ordinating a technical meeting that would bring together community members, researchers and extensionists. The objective of this meeting is to choose the most important problems affecting the experimental area and to set priorities among the research opportunities relevant to these problems. Following the technical meeting, a 'menu' of promising component technologies would be assembled, and these would first be tested in *satellite trials*. These trials would be off-station, located in appropriate agro-ecological niches, and could be managed by farmers or by researchers (depending on the objectives of the trial).

In order to make use of the results of these trials, innovator workshops, organised by the Land Users' Council,⁵⁵ would be necessary. These workshops would be conducted as the satellite trials were set up, and would be held regularly from then onwards. They would have three objectives;

- a) to evaluate the components tested in the satellite trials and to share information about unfamiliar components with farmers,
- b) "to analyze the community inventory of local land use and natural resources in the light of participants' evaluations of high-potential component technologies" [p63],
- c) to produce a community plan for experiments with *combinations* of these component technologies (known as the participatory experimental plan). This plan will define where (in space) to locate farmer-led testing of *combinations* of those components that interested farmers. The trials that result from the implementation of this plan would be known as *participatory system trials*. In effect, they would constitute a farmer-designed, farmer-managed, trial system of land use into which promising technologies

⁵⁵ A body whose functions and compositions corresponded with those of the Land Users' Council was later organised by the member-agencies of CIPASLA. This body was named *FEBESURCA* (*Federación de Beneficiarios de la Subcuenca de Cabuyal*, or Cabuyal sub-Watershed Beneficiaries' Federation). Its performance receives detailed analysis in the following chapter, particularly in pages 186-193.

would progressively be incorporated. Both farmers and researchers would monitor the landscape containing these trials to assess the impact of the new technologies upon biophysical and socio-economic indicators. The innovator workshops would also provide a forum for reporting and exchanging the results of these trials.

This whole process would also provide a valuable framework for a form of dialogue between researchers and land users. The choices made by farmers about whether or not to incorporate particular components (perhaps in a modified form) into the trial system would have been based upon their own criteria for acceptability, including their intuitive assessments of the trade-offs between different production and conservation objectives. As the proposal to IDRC states, "Farmers will intuitively assess trade-offs and make decisions accordingly as they manage the experimental components within a system" [p64]. By monitoring these choices, social scientists would therefore have obtained insights into farmer decision-making, especially when this concerns the choice between alternative technologies. Participatory evaluations with the innovators' workshops would have supplemented this monitoring, helping to make farmers' assessments of trade-offs explicit to researchers. The IDRC proposal thus promised that: "The relative acceptability of different options to farmers will be assessed. Adjustments to technologies made by farmers will be observed [as will adjustments in e.g. labour allocation that farmers make in response to the technologies], as these technologies are incorporated into the existing system of land use by the group of farmers" [p4]. Information obtained in this way could then be used in the process of technology generation to increase the acceptability to users of the next generation of technologies that would be produced.

In addition to the participatory experimental plan the innovator workshops would also have generated hypotheses about causal relationships not readily observable or measurable in the participatory system experiments. Hypotheses such as these are best tested in controlled experiments designed by researchers. These experiments, or *strategic system trials*, will test combinations of components drawn from the participatory trials and will emphasise the study of system-level interactions among them. In this way they will assess the impact of introduced technologies upon key biophysical indicators of sustainability. One important objective will be to study the efficiency of nutrient use in the combinations of components chosen by farmers.

This strategy thus involved undertaking two sets of trials in parallel, farmer-managed *participatory system trials* and researcher-managed *strategic system trials*. The hope was that the latter would both confirm the effectiveness of solutions found by the former and would discover the biophysical principles that explained why these solutions were effective. Again, information obtained in this way would be used in the process of technology generation to improve the next generation of technologies to be produced.

In practice, the Hillside Programme is pursuing this strategy by implementing two distinct but linked projects in the same field sites. One of these concentrates on building local-level organisations to promote sustainable management of the watershed and makes little reference to technology as traditionally understood at CIAT. An eventual objective of this project is to enable the people of the region to exert a “demand pull” for new technologies that would improve production while sustaining the watershed, but this point has not yet been reached. The second project, known as the Inter-Programme Project (IPP), aims both to provide technologies of this type and to elucidate the fundamental principles upon which their design is based. This work was intended to proceed in response to requirements articulated by the communities of the watershed, but in the absence of effective demand from these users the objectives of the IPP were mostly set by the scientists involved. These two projects are examined in detail in the following chapter.

Theoretical Discussion

The earlier parts of this chapter have outlined the plans made for an unusual research and action project. The following chapter will argue that several of the characteristics of this project proved problematic when it was implemented. In order to understand the reasons for these difficulties, this section will consider relevant theoretical discussions of these characteristics. Two distinct discourses will be examined briefly; that relating to development projects as interventions, and that relating to the management of innovation.

Development as Intervention

The project discussed is essentially a *development intervention* — a team of researchers from an International Centre *intervened* in the life of a community, with the intention of effecting various changes that they believed to be desirable. Such interventions, however, constitute processes whose nature and outcomes are negotiated among all those involved — local people as well as researchers and development workers.

Long [1992] considers the interplay between external interventions and local people. He argues that such interventions enter the life-worlds of local people and thus come to form part of the resources available to them. 'External' factors are 'internalised' and often come to mean different things to different actors, while initiatives may come from 'within' as much as from 'without' the community. Indeed, as Villarreal [1992] notes, communication across the interface between 'outsiders' and 'local' groups is not a simple process, since information, ideas and images are reinterpreted and recreated differently by each 'receiver' as well as by each 'sender'. She argues instead that "complex power processes and battles over images and meanings ... take place at [this] interface" [*ibid* p264], influencing the outcomes of development interventions. Intervention, then, is seen as a process shaped by the strategies of local people and by interaction among the various participants and is thus "an ongoing, socially constructed and *negotiated* process with unintended consequences and side effects" [Long 1992a p270, emphasis added].

The above analysis suggests that, as Villarreal [1992] argues, the evolution and outcomes of development projects can only be understood by considering the implications of the recipients' *agency* in the context of the meaning that the project holds for them. The

experience of Laderas confirms this view: as the following chapter will demonstrate, the design of the project in question, its programme of activities and statement of overt objectives were all negotiated among a subset of its stakeholders and thus evolved in response to the exercise of their agency. The eventual nature of the project was thus strongly conditioned by the actions of local people, actions stemming from the *meaning* that it held for them.

Despite their significance, these issues of recipient agency are rarely analysed. Indeed, Nuijten [1992] notes that even those scholars who have considered local-level organisations as a means to 'empower the poor' in fact pay "little attention to the different meanings that local forms of organization have for the people themselves and to the ways in which people use organizational resources" [p202]. For Villarreal [1992], the consequences of this deficiency are serious: "I believe this has much to do with why 'farmer-first' strategies have often achieved such meagre results, ending up either in populist activities which attempt to implement the words of the peasants to the letter, or in manipulative endeavours which present themselves as if they are picking up the words of the farmers, but instead put the words of 'outsiders' into farmers' mouths." [*Ibid* p265]

The above discussion, when applied to the work of Laderas, immediately suggests ambiguities in the role assigned to local people in the plans discussed earlier in this chapter. On the one hand, these plans explicitly acknowledged that the various stakeholders in the project were independent actors, pursuing strategies to advance their own objectives. The project thus involved building institutions that could serve as an arena within which its stakeholders could exercise *agency* in order to realise at least some of their objectives with respect to natural resource management. However, the project design appeared not to take into account the possibility of the project taking on different *meanings* for its clients. In practice, it was to prove vulnerable to (mis)use as a tool for certain stakeholders to advance their own concerns while excluding those of their neighbours. The project had no defences against this outcome.

A related point concerns the manner in which conflicts over natural resources were to be resolved. As argued above, it was critically important that the agreements reached should be regarded as legitimate by all affected parties, since this was the only way to obtain their

compliance. However, this perception of legitimacy is almost certainly dependent upon the agreements reflecting the merits of the case and the resource-management issues involved, rather than the personalities and social positions of the parties to the dispute. In other words, a necessary condition for the success of the project is that the power relations between the watershed's stakeholders should remain outside the arena within which resource-related conflicts are resolved. The work of Nuijten [1992] suggests that this condition is unlikely to be satisfied. She describes how an *ejido*⁵⁶ that she studied, together with the legal and bureaucratic institutions responsible for regulating its affairs, constituted an arena within which local people negotiated solutions to conflicts. The power of such actors, and thus their ability to secure a favourable verdict, depended upon their ability to enrol other members of the *ejido* and — above all — friends and relatives in the bureaucracy. She observed that in presenting their claims within these legal/bureaucratic arenas, “people always need to refer to the official rules because, irrespective of the interests and power struggles involved, ultimately the resolution will be framed in legal terms and discourse. Thus, many [local people] are very skilled at using ... legal discourse.” [*Ibid* p196] This suggests to me that within the new arena created by Laderas, one might expect to observe an environmental discourse being employed to explain the outcome of controversies, but the interests and power struggles involved (themselves expressed through a broader discourse) are probably more important in understanding the reasons for the outcome.

A possible approach to resolving this difficulty is provided by Macleod and Shulman [1997]. These authors consider the models for research and development practice that have been advocated as a means of promoting more sustainable use of natural resources. They note that recent models, of which the work of Laderas is one example, have placed emphasis on empowering stakeholders within a context that may be represented as a political arena. These models are concerned with the management of research, development and extension within a political arena; thus “a major concern becomes understanding the nature and rules of the relevant arena and generating and managing appropriate expectations within the partnerships and alliances therein” [*ibid* Section 2.4]. Awareness of these issues, however,

⁵⁶ The *ejido* is an institutional form that emerged in the wake of the Mexican revolution. Land is owned collectively by the community that farms it, but individuals are granted usufruct rights and engage in own-account farming. The rules that govern access to this land are complex and therefore ambiguous.

is “insufficient to prescribe what might constitute good ... performance or how to achieve such performance” [*ibid*]. Indeed, these models are described as being “incomplete” since they say little about “appropriate communication and management practices for arenas [*sic*] characterised by multiple and changing constituents”; nor about avoiding “undue influence from particular stakeholders leading to less integrative outcomes”. So the authors then propose their Punctuated Arena Model of Research, Development and Extension, in which these inadequacies are addressed by urging the research staff to engage in active management of the arena. This, they argue, is necessary since “Arena Theory suggests that the composition, predisposition, and relative power of different stakeholders will, ultimately, shape the range of possible inputs ... and outcomes”. Such management, they note, “requires skill in activating the interest and engagement of some potential stakeholders and minimising the influence of others throughout the life of a given project” so that managing and changing the arena dynamics is “the major challenge that R&D managers face” [*ibid* Section 3].

Laderas made virtually no attempt to manage the dynamics of the arena in such a way as to modify the power relations between the members of the different social groups present in the watershed. Such management, while essential for the project to function in the manner envisaged by Laderas, would have contradicted the stance of benevolent neutrality that the IARCs have traditionally adopted. Nor would it have been acceptable to the other members of CIPASLA, with whom the task of institution-building was now shared.

The only respect in which Laderas sought to manage the dynamics of the arena was thus its efforts to modify the power relations between CIAT scientists and the people of the watershed. Indeed, a central objective of the project was to institutionalise the capacity to exert effective demand for technology within the community. It thus aimed to empower the people *vis a vis* scientists in such a way that they could effectively press their demands and eventually reach the point of being able “to pull down services to themselves”, thus becoming “customers in the business sense of the word, instead of passive receptors of other people’s output” [Röling 1989, pp144-6]. This was to be achieved by building and strengthening institutions that would act upon the interface between the two epistemic communities. The point at which this interface was to be most explicit, at which the two communities were to confront each other, was represented by the two parallel sets of trials:

the farmer-managed participatory system trials and the scientist-managed strategic system trials. This 'confrontation', it was hoped, would result in a learning process, not only for the farmers but also for the scientists (especially if farmer-management resulted in better results). Comparing the progress of the two different sets of trials would force the members of each group to pay attention to the achievements of the other.

Evidence that this plan was realistic is provided by Long's observation that systematic investigation of processes at such interfaces calls into question the simple distinction sometimes drawn between 'local' and 'scientific' knowledge: "detailed studies not only reveal the creativity and experimentation by farmers but also their continuous ability to absorb and rework outside ideas and technology [so that] it becomes difficult to work with a sharp boundary between 'people's science' and 'scientist's science'. The encounter between different configurations of knowledge involves a transformation or translation of existing knowledge ... " [Long 1992a pp273-4] However, as the Leader of Laderas pointed out, this plan depended upon the success of the farmer-managed trials, which in turn depended upon a considerable effort in building community organisation and in popular education.

Underlying this strategy was a vision of a different paradigm for agricultural research, based upon a different epistemology. Agricultural research has generally proceeded within a Newtonian epistemology and "has relied on reductionist models which left social variables out of the technology development process" [CIAT 1993, p8]. However, as argued above (see pages 92-95), a different agricultural research practice is required if professionals are to deliver technologies that are relevant to the needs of the rural poor. Fundamental to this 'new professional practice' is an acknowledgement that local people constitute an essential component of the system under investigation, so that dialogue with them is an unavoidable part of the research process. The necessity of dialogue means that all such research effectively becomes action research, since measuring something will change it. Dr Ashby observed that this shift, which in cognitive terms she compared with Heisenberg's impact upon Physics, would be deeply threatening to most of the scientists working at CIAT. For this reason, although their collaboration in the project is essential, the full implications of this work have not been explained. Instead, the project is discussed using vague, 'fuzzy' language to avoid threatening and thus alienating them. However, she

hoped that the learning experience of working in the project and observing the progress of the farmer-managed trials would eventually lead many of them to accept the validity of the alternative paradigm.

The Management of Innovation

The organisational significance of this research strategy may be seen most clearly by considering it in the context of current debates around the management of innovation. The first chapter of this thesis consisted of a review of recent research in this area and concluded that while the established 'linear' model of innovation was unsatisfactory, an alternative 'fifth generation' model was less vulnerable to criticism. It was argued that the prescriptions of this latter model provided a more reliable guide to innovating effectively than those of the 'linear model', particularly when researchers lack *a priori* knowledge of their clients' needs. Such 'fifth generation' innovation, it was argued, is characterised by three fundamental principles which represented a new definition of 'best practice' for innovation. These may be stated as follows:

1. useful 'applied' knowledge is not usually derived from more fundamental knowledge but is generated *in the context of application*, a context that is provided by close links between researchers and practitioners;
2. continuous negotiation among stakeholders and researchers, in order to find compromises between what the different stakeholders want and what is technically feasible, is an essential part of the process of innovation;
3. *effective innovation requires new configurations of knowledge and skills*. The same set of specialist technologies and skills may repeatedly be configured in different ways to meet the (changing) needs of (varying) users, so that "the emphasis is on interdisciplinary teams with the maximum sharing of information across functions" [Rothwell 1992 p225].

The project, as planned by Laderas, fully satisfied the above 'fifth generation' principles. Firstly, it was conceived as a concrete intervention in a specific watershed, an intervention aimed at building a "working model ... of participatory research and development for sustainable agriculture" [CIAT 1993 p1]. Moreover, its implementation has involved close collaboration with CIPASLA, a consortium of development agencies. This project is thus

situated within the context of application. Secondly, an important part of this project has been the development of methods to identify stakeholders and to build their capacity to articulate their requirements. The institutions that are to be constructed are intended to enable these stakeholders to negotiate among themselves and with researchers about the kinds of solutions that they would find acceptable. Thirdly, the scientific questions to be investigated by researchers were intended to be defined by the outcomes of community-level experimentation and thus would transcend the boundaries fixed by disciplines or Programmes. Instead, intellectual resources from all parts of CIAT were to be made available to permit an effective response to such problems.

Laderas had thus prepared detailed plans for undertaking a 'fifth-generation' innovation project, although CIAT (of which Laderas is a component) remained an organisation whose structure and culture were predicated upon the 'pipeline' theory of innovation. This arrangement was fraught with potential difficulties: as noted in the first chapter, the characteristic principles of 'fifth generation' innovation have clear organisational implications, which are in conflict with those of the 'linear' model. The following chapter, which discusses the implementation of this project, will consider the ways in which Laderas' activities were conditioned by CIAT's Centre-level characteristics and to some extent were frustrated by the contradiction between the two approaches to innovation. An examination of this experience may elucidate the changes that are necessary if a 'pipeline'-type organisation is to become capable of practising 'fifth generation' innovation.

Conclusions

This short chapter has outlined the research plans made by Laderas, together with the ideas about landscape-level resource management that provided their intellectual foundation. These plans were then critically examined in the light of two relevant theoretical discourses; that relating to development projects as interventions, and that relating to the management of innovation. This discussion has demonstrated that the original decision to define the system of interest as a landscape and to work at this level, together with the explicit recognition that local people are part of that system, led directly to a 'fifth generation' research design. Indeed, one of the (tacit) objectives of the project was to create a situation in which CIAT scientists would experience certain aspects of this approach and thus come to appreciate its power.

One of the defining characteristics of the 'fifth generation' model is the enhanced role given to stakeholders in the innovation. It is perhaps surprising, then, to note the ambiguity with which the agency of local people was regarded. While the project involved building institutions within which its stakeholders could exercise agency in pursuit of their objectives with respect to natural resource management, the possibility that the consequent debates might be resolved on the basis of the power relations prevailing between the actors involved, rather than upon the merits of the case, appears not to have been considered. There was certainly never any question of the researchers seeking to correct the bias that local-level power relations introduced into the conduct of environment-related debates, nor of modifying the power relations that gave rise to such distortions. This apparent inability to take account of the political realities prevailing in the project area is consistent with the stance of apolitical benevolence traditionally assumed by the Research Centres of the CG System.

The significance of this point will become clear in the following chapter, which will examine the implementation of this project and will discuss the ways in which it was modified, both by the specific characteristics of the project area and by those of CIAT itself.

Chapter 5 Implementation

This chapter builds directly upon the material presented in the two preceding chapters. Chapter 3 argued that the structure and culture of CIAT were predicated upon the 'linear' model of innovation, while the fourth chapter discussed the research strategy developed by Laderas and demonstrated that this proposed innovation project conformed to the 'fifth generation' model. The present chapter thus considers an attempt by a 'pipeline'-type institution to undertake a 'fifth generation' innovation project. The contradictions that resulted are used to demonstrate that change in the model of innovation that is practised requires complementary organisational change. Indeed, the implementation of this project constituted an attempt to effect organisational change: the limited effectiveness of the latter suggests that Laderas, as a component of CIAT, had little power to modify the wider organisation.

The research strategy analysed in the previous chapter was eventually implemented as two of the four projects of the Hillside Programme. (The two remaining projects are beyond the scope of this discussion.) This strategy was designed to build a "working model ... of participatory research and development for sustainable agriculture ..." [CIAT 1993 p1] and was intended to be implemented in two stages. The first of these tasks was to find ways to build institutions to promote landscape-level environmental management. These institutions were seen as being a means to develop community-based capacities to exert effective demand for resource-conserving new technology. Only once this had been achieved was the development of these new technologies planned to begin, so that this latter activity could respond to the demand articulated by the community served. In practice, however, the two tasks are being undertaken concurrently, in the form of two distinct but linked projects in the same field site. This chapter will review the evolution of each of these two projects in turn and then discuss the ways in which they are linked together. Finally, a number of conclusions will be drawn from this experience.

Project: Institutional Models for Participatory R&D for improving technology design and adoption in the Hillsides

The primary task of this project was the formation of a community-based Watershed Users' Association. The intention of Laderas was to develop this Association as a forum for negotiation between different interest-groups about resource-management issues and to strengthen its ability to exert effective demand for resource-conserving new technology. In effect, the Association was intended to provide a mechanism that would facilitate communication and control among the various users of the watershed, so that their use of this shared environment would be constrained in such a way that the watershed as a whole would manifest emergent properties associated with sustainability. Furthermore, the negotiations that the Association was intended to facilitate were also expected to develop the capacity of its members to articulate their requirements for new technologies. The activities of the Association would thus equip its members to participate in negotiations with researchers about the characteristics of innovations that were to be developed for their benefit. Since the key role of such negotiations between researchers and stakeholders is one of the defining features of 'fifth generation' innovation, the Association's task of developing the capacity to exert effective demand for new technology is a necessary precondition for effective 'fifth generation' innovation.

The primary project site (the Río Cabuyal watershed around Pescador) is an area in which CIAT has nearly fifteen years experience of undertaking research [CIAT, 1994a]. This site had been the birthplace of the IPRA project, CIAT's earlier work on farmer-participatory research. However, while the IPRA project had concentrated on developing and disseminating methodologies for participatory research and for building organisations of farmer-researchers, the research focus has now expanded from agricultural production *per se* to place production in the much broader context of natural resource management. This means that the research is no longer directed at individual farmers but concerns everyone involved in resource management practices. As discussed in the previous chapter, an inter-dependency exists among different users of the natural resource base, so that the use of a resource made by one group affects (directly or indirectly) the ability of other groups to use the same or other resources. These factors enhance the importance of institutional mechanisms for collective decision-making about the resources managed by the members of

the community and for directing relevant research towards the people involved in these practices.

The Watershed Users' Association, then, was absolutely fundamental to the entire research strategy of Laderas. As discussed in the previous chapter, Laderas had originally intended to begin work by forming the Association and developing its capacity to exert demand for research. The direction of the project was, however, changed at an early stage by pressures from CIAT management (reflecting donor-driven policies adopted by the CG System as a whole). These organisational pressures forced the researchers responsible for the project to enlarge their system of interest, so that it included not only the people of the watershed but also a range of (external) agencies operating there. This meant that they were faced by a greater degree of complexity than they were equipped to handle effectively.

Laderas thus began to implement this project by building links with other organisations active in the project area, with whom it formed a consortium known as CIPASLA. The task of forming a Watershed Users' Association was postponed until the members of CIPASLA had agreed a common agenda, which thus reflected a range of interests external to the communities served (together with the interests of an elite group from within the watershed, which had taken part in the formation of CIPASLA and the definition of its agenda). This agenda then served to define the objectives of the Watershed Users' Association, inevitably influencing the way in which the latter was perceived by the members of different social groups, and thus their willingness to take part in its activities.

The research method followed, then, has involved the following steps (not implemented in this order);

1. Identifying different stakeholders who follow different resource management strategies. The methodology acknowledged that conflicts of interest and differences in the strategies followed could occur between members of different socio-economic and ethnic groups and also between people living/farming at different altitudes within the watershed, enjoying different access to resources. In practice, the members of each community were divided according to the level of well-being (defined in terms of their access to the goods and resources most valued within the community) that they enjoyed. Groups of people enjoying the same level of well-being were formed, so that

differences observed between these groups would reveal the impact of well-being level upon the variables being observed.

2. Gaining insight into the various resource management strategies pursued by different stakeholders and thus into what different stakeholders perceive as problems. These insights into the types of phenomena that are perceived as problems provide an essential foundation for work on strengthening capacities to articulate demands for research. In practice, this task was undertaken by organising discussions within each well-being group. The results of these discussions are passed on to the Inter-Programme Project (see below) to assist their efforts to craft component technologies that different types of stakeholder are likely to adopt.
3. Observing, co-ordinating and strengthening organisations active in the region. This work is predicated on the assumption that in order to re-organise the interface between farmers and researchers, some form of organisation, representing not only farmers but also other stakeholders, is required to formulate and enforce client-driven research agendas. Indeed, the existence of institutional mechanisms open to the entire community, to all the different types of stakeholder, is a necessary pre-condition for the development of community-based capacities to articulate demands for research.⁵⁷ The decision to work through existing groups, rather than creating a completely new organisation, was important: the reasons for this decision are discussed in the previous chapter.

⁵⁷ It is probable that the organisations already active in the region, and the institutional mechanisms that they represent, are *not* open to the entire community but on the contrary act to strengthen and legitimise existing inequalities. If this is the case, including these organisations as full partners from the very beginning of the project could seriously undermine its chance of achieving its main goal. That the staff of Laderas were aware of this possibility is shown by the following paragraph, quoted from p11 of CIAT 1994a;

The first [task involved in organising for client-driven community based R & D research] is to identify institutional mechanisms to which all and particularly the poorest segments of a given community have access. Often local institutions tend to maintain and legitimize existing inequalities within a community rather than contribute to their eradication (eg Gubbels 1993, Pretty and Chambers 1993). Thus, rather than solely relying on existing local institutions, the challenge is to assist communities in creating new institutional mechanisms to meet new and often conflicting needs and to develop ways for these to interface with traditional institutions (Gubbels 1993).

Donor pressure, together with the approach outlined in the Strategic Plan of 1991, overcame these reservations.

Work on the third of the above steps began in 1992, soon after the formation of the Hillside Programme [Ravnborg and Ashby, 1995]. It was clear that a number of organisations concerned with agriculture and the environment were operating within the watershed of the Río Ovejas, of which the Río Cabuyal is a tributary. The policies of these different organisations (including both official agencies and NGOs) were often contradictory, so the Hillside Programme's first initiative was to assist these organisations to coordinate their work related to natural resource management (NRM). Accordingly, they were brought together in a pair of workshops organised by Laderas, and also attended by local community leaders; specifically three (para-professional) extension workers and a representative from a local marketing cooperative.

These workshops resulted in the formation of a consortium known as CIPASLA (for *Consortio interinstitucional para una agricultura sostenible en laderas* or Inter-Institutional Consortium for Sustainable Hillside Agriculture). Since CIAT catalysed the formation of this consortium and supports it as it encounters new problems and develops appropriate procedures in response, the Annual Report of the Hillside Programme [CIAT 1994] refers to an element of action research in this work: Laderas not only observes the development of CIPASLA but also identifies lessons that can be useful to it. At the same time, this arrangement provides CIAT with a number of partner-organisations with whom to work in this area. In particular, it meant that the task of organising the Watershed User's Association was now shared with the other members of CIPASLA.

The consequences of working in this way were far-reaching. The other members of CIPASLA already had their own priorities, reflected in the kinds of development project that they were supplying. The (often heated) discussions that had accompanied the formation of the consortium had clearly shown their lack of consensus on the location and scale of resource degradation and on the relative importance of these and other concerns [Ashby 1995]. However, in the period following the formation of the consortium they chose the *subcuenca* of the Río Cabuyal as a pilot area and succeeded in developing a common agenda for action. This agenda reflected "a supply-driven portfolio of sub-projects that incorporated longstanding programs 'on offer' from the institutions" but these sub-projects were now organised around the fundamental objective of protecting water sources [*ibid* p23]. The processes that led to this choice of objective are worth examining.

Setting the Agenda for CIPASLA

The discussions that took place at the first workshop, held within CIAT on the 25 and 26 November 1992, revealed the depth of disagreement among the twenty organisations that took part. A number of efforts to resolve this problem were therefore made over the following three months, beginning with the formation of a provisional Coordinating Committee. This committee was given the immediate tasks of collecting information about the pilot area and of organising the second workshop; this was scheduled for March 1993 and was intended to plan a joint programme of activities using the newly-gathered information about the area in question [Cabra 1996]. In February 1993, therefore, staff from three institutions within CIPASLA worked together with the local leadership to undertake a 'rapid appraisal' designed to identify the problems perceived as priorities by the inhabitants of the watershed. This work built upon an earlier survey of the *municipalidad* of Caldono (which overlaps the Cabuyal watershed) carried out by the district extension agency, UMATTA (*Unidad Municipal de Asistencia Técnica Agropecuaria*, or Municipal Unit for Technical Assistance to Agriculture).

The rapid appraisal performed by CIPASLA revealed that the watershed could be regarded as consisting of three distinct agroecological zones (of upper, lower and intermediate altitude); and that water shortage was seen as a high priority by the communities of the lower and (especially) middle zones, while the people of the upper zone were more concerned about infrastructure and access to public services. However, the water shortage was widely believed to be related to clearance of forest in the upper zone of the watershed. This view was confirmed by the rapid appraisal: for several community leaders from the lower parts of the watershed, helping to appraise the upper zone made them realize the extent of the encroachment suffered by the forest around the water sources that serve the population of the lower levels. During these appraisal meetings the upper watershed inhabitants explained that such encroachment provided not only farmland but also charcoal, virtually the only source of income available to them. Their view, therefore, was that "if people from the lower reaches of the watershed wanted them to stop clearing the forest for agriculture or charcoal production, then there would have to be some improvement made to their access to the type of services already available to the downstream communities" [Ravnborg and Ashby 1996, p6].

As a result of this experience, the four community leaders who had participated in the original workshops decided to take action, and launched a motivational campaign to promote the conservation of water sources. They were in a strong position to demand that CIPASLA not only support their campaign but also act “to improve the quality of life in the upper watershed as an explicit reward ... for the upland peoples’ commitment to cease cutting and clearing [around water sources]” [Ashby 1995 p19]. This agenda provided the members of CIPASLA with a basis for working together and therefore was adopted as an organising principle for the consortium. At the same time, the leaders themselves began to plan ways in which farmers and organisations from the lower parts of the watershed could help to improve the production and marketing of the produce of the upper zone.

It was at this point that Laderas suggested the formation of a Watershed Users’ Association to the other members of CIPASLA: the community leaders took up this suggestion and used their campaign meetings to promote the new body to the people of the watershed. Nor was this all: “During these meetings they defined the purpose of the user association as being to regenerate and protect the supply of water on which farms and domestic life depend. They stressed the importance of CIPASLA and the watershed users’ association, and of prioritising interventions which would benefit the inhabitants of the upper watershed and motivate them to protect forested buffer zones around the main water sources.” [*ibid* p7] Indeed, these meetings were also used to elect representatives from the communities to serve on the committee of the new Association. Since the community leaders held these elections “in a whirlwind fashion” in the context of their motivational campaign, there can be little doubt that they were able to influence the outcomes, at least to the extent of ensuring that the representatives chosen sympathised with their definition of an agenda focused upon water security [Ashby 1995, p22]. The local leaders had thus used their experience of taking part in organisational processes to ensure that both CIPASLA and the Watershed Users’ Association would address the concern for water and reforestation issues felt (primarily) by the mid-altitude communities.

The inaugural meeting of the Watershed Users’ Association took place in April 1993. Shortly afterwards it was formally constituted and named FEBESURCA (*Federación de Beneficiarios de la Subcuenca de Cabuyal*, or Federation of Beneficiaries in the Cabuyal sub-basin). By this time, however, the various agencies that belonged to CIPASLA had

resolved their differences and agreed to organise their work around the objective of protecting water sources. Since FEBESURCA is in part intended to be a local counterpart for the agencies belonging to CIPASLA, the agencies' focus on projects of this nature inevitably affected the direction of its activities, so that an agenda had already been set for it.

CIPASLA had been formed before the Federation was ready and overtook the latter before it was strong enough to formulate its own agenda. As the Project Manager commented, one could argue that it might have been better to begin by building local organisations within the watershed and so to enable local people to formulate their own needs. After doing this, the external agencies active in the area could have responded to an agenda set by their ultimate beneficiaries. In practice, however, the agencies came first. Together with a few local people (who were concerned about their water supply) they set their own agenda, and this was then followed by the organisation of local people.

The Planning Workshop

One 'arena' within which the local leadership had been able to express their concern that water sources be protected was the second of the workshops organised by CIAT. This five-day planning exercise, held in March 1993, was attended by 18 delegates from the different organisations that belonged to CIPASLA. This group used the method known as Participatory Planning by Objectives to organise the perceptions of its members about conditions in the study area (including the new information obtained by the Coordinating Committee) into a 'problem tree' showing not only the range of issues that they believed should be addressed, but also their views of the links between these problems. This was used to construct a corresponding 'objective tree' and then a 'planning matrix' to match the specific objectives agreed by the group with the activities necessary to achieve them. Indicators of progress and the methods to be used to verify that these had been achieved were also shown in the matrix. Parts of this matrix are shown as Table 1 below.

Specific Objectives	Activities	Indicators (of Success): to be achieved by 1996
1 The community organisations develop the capacity to solve communal problems	1.2 Identify organised groups already active 1.3 Establish norms for communal work 1.4 Give the community training relevant to the projects 1.5 Agree the support to be given by the institutions to groups within the community 1.6 Execute projects to resolve problems most felt by the community	In 50 per cent of <i>veredas</i> , local organisations with support from the institutions will have solved at least one problem <i>más sentido</i>
2 The adoption of practices for managing plant cover that improve soil stability and the regulation of water flow through the <i>cuenca</i>	2.1 Conscientise the communities in the management of natural resources 2.2 Delimit areas suitable for reforestation 2.3 Establish new plant nurseries 2.5 Set aside areas to help natural regeneration of the native forest 2.6 Reforest communal areas 2.7 Establish agroforestry systems around rivers	The members of CIPASLA, with the support of the communities, will have adopted practices for managing plant cover in 40 per cent [of the <i>cuenca</i>], by means of; – protective reforestation in 5 has per year – productive reforestation in 8 has per year – establishment of agroforestry systems covering 5 has in 12 sites each year, specifically in the high-altitude zone of the Cabuyal watershed Twenty per cent of families present in the <i>cuenca</i> will include animal breeding and the use of sub-products in their land The farmers of ten <i>veredas</i> will establish three non-traditional crops with the help of CIPASLA
3 The adoption of several non-traditional methods of production that increase farm productivity	3.1 Strengthen the CIALs 3.2 Study the feasibility of possible non-traditional production methods: choose the three most promising and diffuse them fully 3.5 Encourage the production of livestock and of minor species, and the cultivation of non-traditional crops	
4 A reduction in [environmental] destruction by means of [a move to] alternative methods of production coordinated across the communities	4.1 CIALs to develop and test agroforestry systems 4.3 Train farmers in the establishment and management of agroforestry systems 4.4 Train technical staff [active in the zone] in the technical management of such systems 4.5 Support the establishment of tree nurseries 4.6 Support efforts to protect forests by environmental training	The community of the <i>cuenca</i> , supported by CIPASLA, will establish productive agroforestry systems in twenty per cent (by area) of the zones critical for water sources [the upper level of the <i>cuenca</i>] and in fifteen per cent of the riverside areas in the lower and middle zones of the watershed

5 The adoption of several conservation practices that reduce soil deterioration	5.1 Train farmers in the use and management of different methods to conserve local soils 5.2 Establish and maintain living [erosion] barriers 5.3 Find uses and markets for the products of the living barriers 5.4 Set aside areas of critical erosion 5.5 Technical management of local cattle-breeding	
6 The establishment of two irrigated regions		
7 Strengthening and increasing the efficiency of existing links with markets and feasibility studies for new linkages	7.1 Define possibilities of diversifying markets to reflect changing production 7.3 Identify new products and plan possible ways of marketing them	With the support of external markets, the commercial organisations within the <i>cuenca</i> increase the volume sold by fifty per cent and diversify the markets for three products
8 The performance of programmes of environmental education within the <i>cuenca</i>	8.6 Form ecological groups that promote the conservation of natural resources and raise awareness of the importance of maintaining the ecological equilibrium (flora-fauna) 8.8 Make the people aware of the negative consequences of burning and clear-cutting trees and plants	

Table 1: Selected results of the PROLADERAS Planning Workshop, 15-19 March 1993, based on author's translation of Busquets [1993].

The influence of the community leaders and their water-focused concerns may be seen most clearly in lines 2 and 4 of this table, above all in the indicators of success to be applied to these objectives. The information presented here was later to constitute a significant input to the process of planning the Inter-Programme Project, which will be discussed later in this chapter.

Structure of the Consortium

The processes discussed above led to the formation of a complex of organisations. The name CIPASLA is often used to refer to the entire complex, as well as to the consortium of agencies which is part of the complex. CIPASLA, then, essentially consists of three committees, whose function and composition are as follows (see Diagram 1 below);

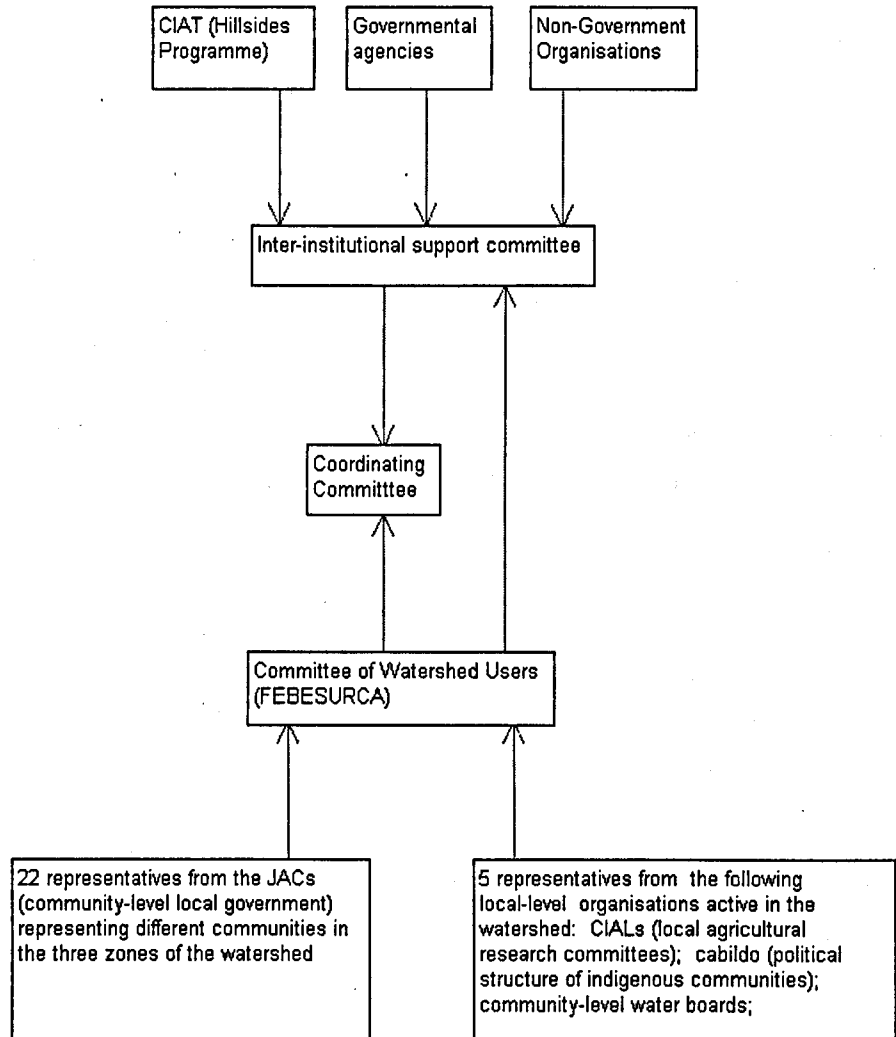


Diagram 1: the organisational structure of CIPASLA
Arrows represent the relationship 'is represented in'

(a) an inter-institutional support committee that represents the various external agencies active in the watershed (including CIAT), and which also includes representatives from the beneficiary committee FEBESURCA. The primary function of this committee is to coordinate the activities of the various external agencies, thus strengthening their ability to

function effectively. The overall objective is to promote sustainable development and to create mechanisms to prevent practices that harm the natural resource base,

(b) a coordinating committee to liaise between the support committee and FEBESURCA (see below),

(c) a committee of watershed users, the immediate beneficiaries of CIPASLA's projects, known as FEBESURCA. Since FEBESURCA is a federation, this committee includes representatives from local-level organisations active throughout the watershed, as well as from several communities within the three zones. This committee supposedly represents the various interests and needs of the people living within the watershed (but not downstream users of the water) and can therefore (1) provide knowledge about problems (needs) in these communities, (2) identify mechanisms through which action can be taken in response to such problems and (3) encourage communities to request projects to resolve them. Since the Federation manages its own budget to finance such projects, it has needed to develop procedures for evaluating, prioritising and implementing the projects proposed by the communities. In addition, it is expected to *link* the relevant communities with agencies that can provide appropriate technical support (usually members of CIPASLA). The role of FEBESURCA is thus two-fold. In the short term, it provides information to assist CIPASLA in its work in the region. In the longer term, its operation is expected to strengthen the ability of the communities to exert demand for technical services, while providing an institutional mechanism for transmitting this demand to sources of supply.

Role of the Consortium

The whole structure is intended to function as a 'platform' (in Röling's language) where conflicting interests can be represented and conflicts of interest can be resolved through negotiation, guided by expert scientific knowledge supplied by the agencies represented in CIPASLA on the ecological consequences of pursuing different strategies. CIAT's work on simulation modelling and decision support systems is seen as being important in facilitating these negotiations. Such expert knowledge is seen as being relevant, both to negotiations and to the resultant definition of strategies. Equally, the participation of all relevant interest

groups, together with CIPASLA's efforts in environmental education, are seen as vital in obtaining comprehensive compliance with the agreement reached.

It seems clear that the end-product of these negotiations will in most cases be agreement on strategies to maintain or increase production in an environmentally sustainable fashion (since it is unlikely that any strategy that depended on reducing output would be adopted). Both material resources and technology will be required to implement the majority of strategies agreed in this manner. In some cases, where the technology required has already been developed, the external agencies belonging to CIPASLA will be able to supply what is required. In other cases further research will be required. Since the Inter-Programme Project is now working in the same location to develop Prototype Systems for Sustainable Hillside Agriculture, it could eventually have a role in responding to this demand.

In sum, this project is developing and applying a form of 'social technology'. While it results from an initiative on CIAT's part, its success is critically dependent upon the active participation of its clients. The task faced by these clients (collectively deciding how to manage the landscape within which they live and work) will, it is hoped, be made possible by the structures built by the project. This task should be facilitated by using the decision support systems (incorporating simulation models and expert knowledge about the dynamics of landscapes under different management regimes) that CIAT's Hillside Programme is also developing (another supply-led development, but in the expectation that demand will be created). The ultimate objective is to institutionalise demand for the new technologies that will be necessary to implement whatever 'management plan' emerges from negotiations among the project's clients. Intimate linkages with possible sources of the technologies required, such as the Inter-Programme Project, would therefore contribute significantly to the long-term success of this work.

The Weakness of FEBESURCA

As discussed above, the formation of FEBESURCA departed from the model outlined in the previous section, in that the nascent organisation was strongly influenced by a relatively narrow range of stakeholders. As we shall see, the remainder of FEBESURCA's participants were thus placed in a submissive role, which offered few or no opportunities to

develop confidence, nor to learn how to express their views and to resolve resource-related conflicts on the merits of the case. And since an agenda had already been set for FEBESURCA's activities when it was first presented to the people of the watershed, it did not attract the participation of those people who did not support this agenda, and thus represented only a subset of the interests present in the *cuenca*. Indeed, the manner in which this agenda was pursued tended to distract FEBESURCA's participants from such fundamental issues.

The FEBESURCA committee developed a range of projects to implement the agenda that they had inherited. Financial support for these was readily available; CIAT's involvement had resulted in the donation of substantial sums of money for this purpose. Indeed, this introduced a certain urgency to the task of finding acceptable projects so that the money could be spent. The attention of FEBESURCA's committee was therefore fully occupied by the search for suitable projects, which may partly explain why the original agenda had not been challenged.

The Project Manager (a Research Fellow with Laderas) also believed that this concentration on projects had excluded other possible activities, such as articulating demand for new technology. She felt that these projects were "not very interesting"; there were few efforts to combine production and conservation objectives and little evidence of any concern for externalities, although these considerations are of critical importance for resource management. A Senior Research Fellow suggested that the projects had these (unsatisfactory) characteristics because the committee members' understanding of the concepts of sustainability was still extremely limited, and because they had not yet been exposed to the possibility of resolving a range of problems associated with environmental degradation. Nor did they have access to technologies that would enable them to maintain production but in a more sustainable fashion, and without understanding the underlying concepts they were unable to demand such technologies.

Two specific weaknesses of the *oferta tecnología* (the set of technologies that could be offered to the people of the *cuenca*) were identified by the Project Manager. The first was the lack of any 'green' methods to control pests and plant diseases, so that the farmers of the watershed had no alternative to the application of toxic agro-chemicals. The Inter-

Programme Project (IPP, discussed below) did not include methods of Integrated Pest Management (IPM); these had been part of the original plan, but including them in its early stages had not proved practical. (See the discussion of this point on page 203.)

The second weakness was the very limited range of methods for maintaining or renewing soil fertility that was available to the farmers of the *cuenca*. Traditionally, *gallinaza* (chicken manure) was widely used as an organic fertiliser, but this practice attracts a range of pests and also causes pollution problems, particularly since farmers tended to apply large quantities, perhaps more than was necessary.⁵⁸ The lack of alternatives for *gallinaza* lay behind several of the problems that were articulated by local people.⁵⁹ While Laderas' staff were aware of several alternative technologies that might reduce the need for *gallinaza*, these technologies had not been properly evaluated and so could not be recommended. For example, while the IPP included trials of green manures and leguminous cover crops, neither the labour input that they required nor their economic (as opposed to agronomic) feasibility had been evaluated: the skills necessary to conduct these evaluations were simply not available to the IPP.

FEBESURCA's dependent status

Another important factor was the imbalance between CIPASLA and FEBESURCA, in terms of both consciousness and power. As was noted above, the member-institutions of CIPASLA effectively set the agenda followed by the Federation from its foundation, and this leader-follower relationship persisted. Thus, a report on relations between the two notes that the staff from CIPASLA showed "an estrangement and an attitude of impatience, even of contempt. They were not attentive to the group processes that took place in meetings (they often spoke among themselves, sometimes they did not tell the others about the decisions they had taken, sometimes they consulted them but then made changes, they did not even have lunch with them)." [My translation of Brekelbaum 1996, pp7-8]⁶⁰ The

⁵⁸One broadly-applicable finding of the IPP was that farmers were applying excessive quantities of *gallinaza*. This finding resulted from the use of *gallinaza* as a fertiliser for the IPP trials, part of a strategy of basing the experiments upon local knowledge and practice wherever possible.

⁵⁹These were listed as concerns about soil fertility; difficulties in obtaining credit to buy *gallinaza*; and the lack of a market for this in areas with inadequate transport.

⁶⁰The original text reads as follows: En las reuniones, no están pendientes de los procesos grupales (charlan entre sí, no comunican decisiones tomadas o consultan y después hacen cambios, no comparten la hora del almuerzo). ... Por lo general los profesionales científicos y técnicos tienen un estilo de liderazgo

author speculates that this reflects a general problem: "Professionals, especially scientists and technicians, often have a style of leadership that is scarcely participatory. This is because they tend to give priority to efficiency and to scientific understanding, while participatory processes take a lot of time and this makes them impatient." A key example, she suggests, has been the relationship between CIPASLA and the comisiones (working sub-committees) of FEBESURCA. Thus, the Comisión de Trabajo ceased to hold meetings because the team from CIPASLA had a tendency to programme events unilaterally. Perhaps more seriously, the professionals had reversed a decision taken by another comisión, destroying the confidence of its members and making them feel that their discussions had been a waste of time. Her account of this incident reads as follows:

Last year the Projects *Comisión* decided that a project in Ventanas [one of the *veredas* or communities in the watershed] should be executed in stages because at that time the *Fondo Verde* [the relevant budget] was not very large and it was not felt appropriate to allocate all of this fund to a single *vereda*. But then the representative of this *vereda* complained in a full meeting, saying that they would never be able to advance anything if it wasn't all done at the time. Magnolia Hurtado, the CIPASLA coordinator, agreed with this representative that the best thing was to do all of it at one time. Then a member of the *Comisión* who was sitting near to me remarked in a low voice 'In that case what the devil were we doing?' This is one example of how the vitality of a group can be destroyed because they see that the professionals end up taking the reins and managing everything in their way. From the technical point of view she was certainly right, that was the best strategy, but this choice undid much of the growth and development that the group had undergone.⁶¹

On the other hand, she described the members of the FEBESURCA committee as paying excessive homage to traditional community leaders and as displaying a timid, submissive attitude: "At first almost none of the representatives wanted to express their opinions in front of the group ... instead they mentioned things to their friends or to technicians outside the meeting but not during it. They had complaints ... but they did not express them openly nor use the proper channels for this." She warns of the consequences of this failure to bring forward conflicts for resolution in the arena developed for that purpose, a failure which

poco participativo porque para ellos prima el conocimiento científico y la eficiencia (los procesos participativos toman mucho tiempo al principio y eso les impacienta).

⁶¹ The original text reads: El año pasado la Comisión de Proyectos había aprobado un proyecto de Ventanas [Ventanas is one of the communities of the watershed] para ejecutar en etapas porque en ese momento el Fondo Verde no era muy grande y no se podía asignar todos los fondos a una sola vereda. Entonces el representante veredal reclamó en la reunión, diciendo que nunca iban a poder adelantar nada si no hacía todo a la vez. Magnolia Hurtado, la coordinadora de CIPASLA estuvo de acuerdo con el representante de Ventanas y que lo mejor era hacer todo de una vez. Entonces un miembro de la Comisión que estaba sentado cerca a mí comentó en voz baja: 'Entonces qué diablos estamos haciendo nosotros?' Eso es un ejemplo de cómo se puede desanimar un grupo porque ven que los profesionales terminan tomando las riendas y manejando las cosas a su manera. Desde el punto de vista técnico, seguramente ella tenía la razón, que era la mejor estrategia; pero desde el punto de vista de la autogestión, no.

could indeed be fatal for the Federation's ability to function as a 'platform': "If they don't learn how to make these complaints through the proper channels and to speak in front of the whole assembly, the capacity to manage conflict in a positive fashion will never be developed." [*ibid* p5]⁶² It may be instructive to reflect upon this weakness of FEBESURCA as an organisation in the context of the substantial responsibilities that had been assigned to it in the planning process (discussed in the previous chapter).

Such weaknesses of FEBESURCA were seen clearly at a committee meeting in March 1996, when it was clear that the CIPASLA coordinator (a salaried professional) was able to determine the outcome of the decision-making process. Voting took place in full view of all those present at the meeting, so the coordinator was able to scold those who voted against her preferred option until they 'changed their minds'. The Project Manager noted that this behaviour reflected the lack of accountability felt by committee members to the communities or interest groups that they supposedly represented. Instead of voting in accordance with the wishes of their constituents, they voted as individuals and therefore were susceptible to pressures such as that observed.

The issue that had been considered by the meeting in question was also revealing. This was a proposal that FEBESURCA should disburse funding for projects in the form of loans, rather than making grants, as had been the case up to that point. Part of the reason for this proposed change had been the belief that many grants were being obtained fraudulently. Since a loan is less attractive than a grant, this change would reduce the incentive for fraud. However, the staff of Laderas felt that it was still easy for the FEBESURCA committee members to secure funds for projects that primarily benefited themselves and their families (thus falling outside the Project's guidelines) since community members were not well-informed about such activities and were unable to hold their representatives to account. Indeed, the Federation lacked the resources required to monitor the projects that it supported, while the representatives had no incentives to 'inform' on abuses committed by each other: the reverse was the case. One possible solution would have been for CIPASLA to accept the responsibility for the monitoring required. Certainly, CIPASLA did possess

⁶² Al principio casi ninguno de los representantes quería expresar sus opiniones frente al grupo ... [sino] comentan cosas con amigos o con técnicos fuera de la reunión pero no durante ella. Tienen quejas ... pero no lo expresan abiertamente o no usan los canales debidos. ... Si no aprenden a canalizar estas quejas y hablar frente a toda la Asamblea, no se logrará manejar el conflicto en forma positiva.

the resources necessary to undertake this task; however, such a change would mean that the communities (and their organisation) would lose an opportunity to learn how to manage their budget for themselves.

It seems clear that, to use the language of Long [1992], the meaning that Laderas attached to FEBESURCA was not shared by the people of the watershed. The view of the Project Manager was a little more explicit: she felt that the Federation was too "conventional" and that this limited its ability to function as a platform for conflict resolution, as had been envisaged when the project was designed. Another limitation to this ability, and one that only became apparent some time after FEBESURCA had begun to operate, was that certain important conflicts over natural resource use were excluded from its jurisdiction since it did not represent some of the interest groups involved. Indeed, subsequent analysis revealed that only a certain section of the multiple interests relating to the management of the Cabuyal watershed were represented in the Federation [Ravnborg and Ashby, 1995]. The net result was that it was unable to evolve as an effective mechanism for channelling demand from a wider constituency.

In part, this outcome resulted from the way in which FEBESURCA had originally been presented to the people of the watershed: as an organisation whose purpose was the protection of the water sources in the upper level of the *cuenca*. This agenda was not a priority for certain stakeholders, who therefore declined to participate in the Federation. Two such excluded groups of stakeholders were the poorer households of the upper part of the watershed, and virtually all households of the lower zone.⁶³ Another factor was the composition of FEBESURCA's committee, which included representatives from the communities of the watershed and from the local institutions present in the area.⁶⁴ All of

⁶³ The poorer farmers of the upper level had little reason to support protective reforestation around water sources. The livelihoods of many of them depended upon land situated at the margins of the very forest that FEBESURCA aimed to protect, and which offered their only hope of expanding their landholdings. Meanwhile, the people of the lower level believed that any increase in water supply resulting from these efforts in the upper zone would merely result in a rise in consumption in the middle zone: their own supply would be unaffected.

⁶⁴ The local organisations represented were mainly the various JACs (*Juntas de Acción Comunal*, the lowest level unit of non-indigenous local government in Colombia) which are responsible for planning and implementing community activities; but also included the CIALs (see the discussion of the IPRA project in Chapter 3 page 112); the local indigenous government; the local aqueduct committees. Ravnborg and Ashby [1996] analysed the participation of different social groups in these organisations and concluded that a "critical feature of FEBESURCA's member institutions, and thereby of FEBESURCA, was the bias against representation from the lowest well-being category households ... [so that it lacked] any

these *local* institutions had been invited to send representatives to the committee; only some chose to do so, so that a self-selected subset of these institutions (themselves representing only some of the interests in play) were represented on the committee. And the formation of this committee, including the subsequent election of community representatives, coincided with the 'motivational campaign' conducted around the conservation of water sources by influential members of the communities in the lower parts of the watershed. FEBESURCA thus represents those segments of the local population that participate effectively in local-level institutions and/or that are acceptable to the leaders of the community; other interests are excluded.

To recapitulate the argument so far: The overall strategy of the Hillsides Programme had been to begin its work by developing community-based capacities to exert effective demand for resource-conserving new technology. The intention was to form a community-based Watershed Users' Association, to develop this as a forum for negotiation between different interest-groups about resource management issues and to strengthen its ability to exert effective demand for technology. Only once this had been achieved did Laderas plan to begin developing new technologies, so that this activity could respond to the demand articulated by the users of the watershed.

Furthermore, the strategy for generating technology depended upon the institutions to be set up around the Watershed Users' Association, to which an extremely wide range of responsibilities had been assigned. Thus, for example, the innovator workshops (supposedly to be organised by the Association) were to perform the essential tasks of analysing the results of the satellite trials and planning the participatory system trials. These trials in turn were to generate the hypotheses that would be tested by the strategic system trials; only at this point would it be useful for the latter trials to begin. However, FEBESURCA has yet to begin exerting effective demand for technology, for the reasons discussed above. In the absence of this demand, and of the institutions and activities around FEBESURCA that had been envisaged in the original strategy, the strategic system trials that are now taking place as the Inter-Programme Project cannot possibly fulfil the role assigned to them in the original strategy.

representative able to articulate the interests and concerns of the poor, including those of the Indian community" [*ibid* pp7, 9].

The Inter-Programme Project, then, began at a time when the information and the institutional framework that had been intended to provide its direction were not yet effective. The reasons for this perverse timing are rooted in CIAT's own internal politics. From Spring 1993 onwards the Hillsides Programme had come under pressure to plant some trials, and to do so quickly. Until then, Laderas had been concentrating on simulation modelling and on organising CIPASLA. Observing this, critics based in other parts of CIAT argued that since it was not performing experiments (as normally understood at CIAT and elsewhere in the CG system) it could not be performing 'real' research. This coincided with a financial crisis, so that there was a real possibility that the Hillsides Programme would be closed down. There was therefore considerable pressure to demonstrate that this Programme was also performing some 'real science', as understood by the members of other Programmes, and to be able to show something tangible such as a trial site to interested observers. Another consideration was the offer, made to Laderas in December 1993, of part of the time of relevant specialists from other parts of CIAT (as explained in Chapter 3). Unless this offer was taken up at the time, it was clear that this resource would be absorbed by other commitments. Accordingly, Laderas responded to this pressure and went ahead with planning the IPP Systems trials.

The Planning by Objectives session which marked the beginning of the Inter-Programme Project took place at a time when FEBESURCA was not performing effectively. Therefore, the objectives were chosen in the absence of inputs from the clients in the region. The Laderas Project Manager (responsible for the project concerning Watershed Users' Associations) argued that these objectives were far too economic, lacking sufficient concern for issues such as water and bio-diversity. In practice, she argued, "the IPP is a collection of plot-level researcher-managed trials: we simply don't know how to work at landscape-level. And there are no effective links between FEBESURCA and the IPP." Instead, the form of these trials reflected the experience gained in the savannahs, since at this time the Savannahs paradigm (essentially cropping systems work, as discussed in Chapter 3) was driving NRM research at CIAT, and it was difficult for the Hillsides Programme to challenge this. The undesirably early start to the Inter-Programme Systems trial thus reflected a strategy for the survival of the Hillsides Programme in an atmosphere of crisis.

Inter-Programme Project: Prototype Systems for Ecologically Sound Intensification of Production in the Hillsides

This project originated in the plans for Strategic System trials that were a significant component of the research strategy developed by Laderas and discussed in Chapter 4. The financial crisis and consequent 'hiring freeze' of this period (discussed in Chapter 3) made it impossible for the Hillsides Programme to recruit the bio-physical specialists required to implement these plans: Laderas therefore concentrated on simulation modelling and community organising, despite mounting pressures from other parts of CIAT to undertake 'scientific' research of the kind normally performed by IARCs.

In December 1993, however, the CIAT Board decided that there should be a move towards a more cross-Programme, project-based style of working. This decision made it possible for Laderas to undertake bio-physical research by using part of the time of relevant specialists from other parts of the Centre. The project that resulted was known as the Inter-Programme Project, and was implemented at two distinct field sites, one in the Colombian Andes and one in Honduras. Only the first of these will be discussed in this thesis.

A fundamental objective of this project was the development of methodologies for the management of renewable natural resources at the level of the landscape, rather than at that of the plot, farm or ranch. This meant that the system of interest was defined at a higher level than that of the individual commodity, the level at which the staff of CIAT's Commodity Programmes were accustomed to working. Since the initial specification of this project represented a departure from CIAT's established paradigm, considerable effort was devoted to the process of defining its objectives. I shall argue, however, that for the most part the nature and objectives of this project were determined by CIAT's earlier experience and by the collective assumptions that arose from that experience. In other words, the research system determined the problem that was to be addressed.

One of the (tacit) objectives of this project had been to create a situation in which CIAT scientists would experience certain aspects of the 'fifth generation' approach and thus come to appreciate its power. Such experiential learning would, it was hoped, lead to changes in the manner in which the scientists involved conceptualised their work and its context and would be reflected in an evolution of the project's definition and objectives. I shall

demonstrate, however, that in practice CIAT's history and organisation severely limited the scope for such learning to take place.

Reasons for the Project

It is not clear why the idea of project-based, inter-Programme work was promoted in this way. One Programme Leader speculated that this decision reflected CIAT's need to save money: the fact that people who were already employed by the different Programmes were to be assigned to the new project certainly meant that it was attractive in financial terms. Although it was not possible to extract more work from the people involved, it was possible "to re-distribute people and cover issues and positions that they had publicly promised to cover, work that they had said they were going to do. They were able to have people working in those areas, but obviously it slowed down the research, since somebody working full-time on a project can do a lot more than somebody working for 20 per cent of the time. So, on paper they were able to create a larger portfolio of work with the same number of people, but obviously there were trade-offs for this." For another Leader, this decision was part of a strategy for survival in a very uncertain environment. Since the Administration cannot predict what donors will want to finance next year, they try to ensure that they are undertaking as large and diverse a portfolio of work as possible, to maximise the probability that it will include whatever topics donors favour next. This strategy does, however, exclude the possibility of striving for excellence in the areas that CIAT perceives as being of highest priority while persuading donors to support this work: a strategy that would have been more attractive for the active researchers at CIAT.

It is also possible that it was the desire to undertake more inter-Programme projects that led the administration to assign people from different Programmes to this project (incidentally saving money). One Leader noted that at this time the Board was anxious "to link the Programmes or even to do away with the Programmes and go to a project-oriented focus. What they wanted was accountability, which is easier at project level than at Programme level." There had already been one (half-hearted) attempt to push the Centre into a mode of working based on cross-programme projects, when the administration had held back some funds from the Programmes in order to support such projects. In practice, this measure had not been implemented: the Commodity Programmes had argued that they needed the

'hold-back' funds in order to meet their existing commitments, and the administration had accepted this argument and handed over the money. For another Leader, this attempt had been half-hearted and no serious attempt was made to implement it, reflecting a lack of high-level commitment to resource management research.

An (acting) Leader of the Hillside Programme concluded that both of these considerations had played a part in the Board's decision "but I would say that it was driven 90 per cent by economics". He therefore believed that the trial of prototype systems — the Andean component of the Inter-Programme Project — "was purely an opportunistic creation ...[that] occurred because of a hiring freeze, because that expertise existed in another programme and we were assigned portions of those people." Had it not been for the financial crisis and the consequent freeze on recruitment "the people that would have done that work would have been hired by the Hillside Programme and the work would have been done as a Hillside project. ... But as soon as there was a financial crisis, the donors began to look for creative ways to leverage funds. ... And that is good, because it forced people to reconsider and to look for other options." In the case of this project, its inter-Programme nature was used to good effect. From its beginning, it included not only the bio-physical specialists whose skills would have been necessary to implement the original plans for a Hillside project, but also germplasm experts from the Commodity Programmes. As the Leader (quoted earlier) commented: "It's logical, when you have that type of trial, to have input from Programmes such as Beans and Yuca [Cassava]". And he noted that comparable developments were taking place on different scales throughout the world of International Agricultural Research: "They have not only done this with scientists within Centres, but also at the level of Centres themselves. That is why you have these cross-Centre initiatives."

Preparation for the Inter-Programme Project

Preparation for the new project began immediately after the December 1993 Board meeting. As a sign of the importance attached to this initiative, all the Programme Leaders met to decide how it should be implemented and which members of their Programmes should be involved. Several of the Leaders were familiar with the work on prototype systems that had been conducted in the Colombian *llanos* (discussed in Chapter 3), which they saw as

representing a paradigm for CIAT's research on natural resources management. On the whole, therefore, the scientists whose time was offered to execute the new project were chosen because of their contribution to this earlier experience. Among these was the senior scientist in the Lowlands Programme who was selected to manage the new project.

Over the next six months, the Project Manager, while continuing to be based in the Lowlands Programme, studied the information on CIPASLA's objectives that had been defined by the Planning Workshop (discussed above, see pages 182-184). This workshop had also "identified problems and objectives for research in the context of a broader set of development and resource management problems faced by the participant organisations" [CIAT 1994a], information that was particularly relevant to the new project. Using this information (summarised in Table 1 above, page 184) as a starting point, he undertook a technological diagnosis of the province of Cauca, identifying the organisations active there on topics relevant to the project in question. Together with two members of Laderas, he spent a month working to diagnose local problems and to define a role for CIAT (identifying CIAT's comparative advantage in this context). This was achieved by visiting local institutions, by interviewing farmers in the region, by holding discussions with the agencies belonging to CIPASLA, by conducting a literature survey (including 'grey' literature) and by examining historical surveys.

Over this period, as the diagnosis proceeded, it became clear that while many development projects were being implemented in Cauca, the technologies being developed and the projects themselves lacked continuity and were poorly coordinated. As the Project Manager explained in interview, much of this work appeared to have been undertaken in response to fashion, and therefore lacked any sustained effort. It was therefore important, he believed, that CIAT should undertake a piece of *long-term* work and should perform it with the necessary *scientific rigour*.

At the same time, as the definition of the problems and of CIAT's role became progressively sharper, it was increasingly apparent that expertise relevant to the new project existed all over CIAT. In several cases, the scientists already involved suggested the names of colleagues who would be able to make a significant contribution. In this way, key people from all of the Programmes were identified and invited to take part in the main

planning session. However, since this was CIAT's first attempt to undertake inter-Programme work it was only possible to 'pull in' a limited number of people from other parts of CIAT. On the whole, therefore, those who were involved initially were the closest colleagues of the Project Manager: bio-physical and soil scientists from the Lowlands Programme. Certain germplasm specialists also felt able to take part, since the commitment that this represented was little more than to supply appropriate seeds, although many contributed far more than this. For example, a cassava specialist "wanted to collaborate with the evaluation of the cassava lines under those conditions. So I went to him, he looked for the germplasm and his people have been monitoring what is happening to that germplasm."

Relationships formed in the course of the systems work in the *llanos* were also important, as the Project Manager explained. "Previously, I had collaborated with the Rice people in their Lowlands work. So we had an open discussion and considered the idea of growing rice in the Latin American Hillsides, as in the Asian Hillsides. And then they got involved, and now we have rice lines included in the Systems trial. They are involved in the supply of the germplasm and in critical evaluations, and they are working towards [providing] germplasm to satisfy the needs that we are identifying at the moment." The Leader of Laderas added that the decision to include rice in the trials was partly taken in response to the desire expressed by CIATs for some means to diversify their crops and increase their food security. Of all their staple foods, rice was the only one that could not be grown in the Hillsides, so it was natural to try to find a variety that could be introduced into this environment.

Planning the Inter-Programme Project

It was in September 1994 that this mixed group of specialists from all of CIAT's Programmes met to plan their joint project. As the moderator of this meeting recalled: "At that time we had come under a lot of pressure from CIAT administration to come up with the projects. It was something that we launched into with about a month or two to get them done, so everything was quite hurried. At that point we were just trying to get things started." The timing of this meeting, nine months after the Board's decision to allow pooling of expertise from across the Programmes in projects such as this, might seem a

little surprising. It should be remembered, however, that the nine month delay had coincided with the traumatic period in which the financial crises (discussed in Chapter 3) had culminated in the nervous illness and subsequent departure of the Director General. Decisions are not usually made rapidly under such circumstances.

The discussions that took place at this meeting were structured by a method known as Planning by Objectives (PPO, for the Spanish term *Planificación por Objetivos*). This method was originally developed by GTZ (*Deutsche Gesellschaft für Technische Zusammenarbeit*, the German technical agency for international cooperation) and is often known by the German acronym ZOPP, for goal-oriented project planning. As Collion and Kissi [1993] explain, two features of the ZOPP method are the *structured logic* with which a hierarchy of constraints is constructed, and the *visualisation technique* to show the relationships between different ideas put forward in discussion. They explain these features in the following terms;

[A] constraints chart is developed, with a central, general problem at the top. The next level down presents a number of the general problem's causes and succeeding levels present the causes of each of these. The constraints chart, constructed through an interdisciplinary and multivantage-point process, circumvents the 'blind spots' of specialists and obtains a comprehensive analysis. ... The visualization technique requires participants to summarize their idea [about a given theme] in a few words. Each idea is presented on a card. [These cards are then displayed on a corkboard so that the ideas] can be discussed by the participants. ... Visualization techniques encourage participation and ensure that ideas are not overlooked. They help focus discussion and prevent circular arguments. They aid in developing consensus without more senior or more articulate individuals dominating debate. [*ibid* pp264-5]

The PPO of September 1994 was moderated by the Leader of the Bean Programme, one of the few people at CIAT who regularly takes part in PPOs. As she explained, "a PPO is a participative planning method" that usually runs for five days, in which the group of participants establish the overall goal, purposes and specific objectives of the activity planned. The group's first task, then, is defining the problem to be addressed, although she made it clear that use of the PPO is only appropriate if "you have some kind of general objective when you are going into it, some idea of why you are holding a PPO". This is followed by a series of exercises: the problem tree (or constraints chart) is developed, then "you go from the tree of problems to the tree of results, how do you solve those problems? So you have all these problems that you want to [address, then elaborate upon these 'results'] to develop the activities to achieve those results. And from there you go into a logical framework matrix or breakdown of work structure, in which you elaborate the exact

activities that will take place, who has to do what.” However, as she also said, “the nice thing about a PPO is that nothing is ever written in stone but you always go back and do it again and modify it. After a couple of years you look at it again, and maybe the objectives have changed, maybe the problems have changed, maybe there is a new way of tackling the results.”

Dr Knapp later confirmed that he saw this project as being a stochastic process which cannot be rigidly defined in advance, but whose direction depended upon the participation of those involved:

Decisions will have to be made in the future about issues that we haven't addressed at this point (such as trial treatments, how things will be done, measurements that will be taken). Those decisions will be made as we arrive at certain points in the work. So it is not as if we had sat down like mechanical engineers designing a machine, and all that we were doing now is just carrying out the plan: there are some things that will have to be addressed in the future that we haven't been able to address now. I am sure that at the moment we are going down some dead ends, and we will have to cut that work and look in new directions. The important thing is to get the right people working on that project and it will work.

Involving “the right people” at every stage is thus vital for the success of the project. This insight is particularly relevant to the initial planning exercise: the outcome of a PPO must surely reflect the perceptions held by its participants of the nature of the problem-situation to be addressed. Collion and Kissi [*ibid* p267] therefore advise that the group of participants in such an exercise “should be chosen carefully to represent a wide spectrum of expertise and experience”. They warn that if this advice is neglected “results are biased and may be of little practical value” since “[n]o matter how rigorous the planning method, the outcome will be no better than the expertise and experience of the group”. However, the majority of the participants in the PPO under discussion had been selected because of their exposure to research on prototype systems. This may explain the comment, made by the (acting) Leader of Laderas, that “the planning by objectives session was largely dominated by the production or bio-physical types”.

In addition, the “general objective” for this PPO had been provided by the results of the CIPASLA Planning Meeting (March 1993) summarised in Table 1 (above, page 184) and by the subsequent investigation conducted by the IPP Project Manager. This investigation had revealed that Objective 4 (a reduction in [environmental] destruction by means of [a move to] alternative methods of production coordinated across the communities, seen as

involving the coordinated establishment of agro-forestry production systems in areas close to water sources) was of “critical” importance, while people in Laderas had signalled that it was a very high priority for their clients within the watershed. Therefore, as the Leader who had moderated the PPO recalled, “we defined [the problem] as the need for more productive or sustainable cropping systems ... and went right into the work on prototype systems”. The group of participants was then responsible for deciding what this meant, and what should be done by each of its members. “The idea was to get down to some level of detail about collaborative activities in this one particular area. That was the general purpose of the exercise, and then they went on to discuss what were the major problems, and a whole series of problems were identified; soil erosion, low-yielding crops, a lack of rotation crops, poor maintenance of fallow areas, degraded pastures, a general series of problems were [identified by the people in the meeting].” All of these problems were to be addressed by the prototype system that would be developed. The project activities, then, were defined in order to achieve this.

Project Design

‘Win-win’ technologies

The project that resulted from the planning process discussed above was predicated upon two assumptions about the typical hillside farming system (described as short-cycle, shallow-rooted monocrops rotated with native pasture for grazing livestock⁶⁵); that this system

- (i) is prone to soil loss and deterioration of soil quality,
- (ii) does not yield sufficient output to meet the perceived needs of the farmers.

The literature surveyed at the beginning of the project indicates that it is necessary to approach both of these problems simultaneously. In many of the cases reported, effective technologies for soil conservation would have reduced the net income accruing to the

⁶⁵The accuracy of this description is far from certain. Aerial photographs of the hillsides ecosystem, analysed by CIAT’s GIS unit, indicated that 50 to 70 per cent of this region was covered by coffee-banana inter-cropping, which provides very good soil cover (both coffee and banana are deep-rooted plants). Survey data on the same region showed that most farmers regarded fields planted to these crops as being the most important; the fields for such crops as cassava (where mono-cropping is most prevalent) are of only residual importance.

farmer during the first 40–60 years of their use and so were not adopted. Another body of literature reported many experiences with technologies that increased output and incomes but also seriously exacerbated the degradation of the hillside environment.

For these reasons, the objective of the Inter-Programme Project is to generate 'win-win' technologies that simultaneously meet conservation and production needs. In practice, such technologies are expected to be new arrangements or combinations of crops (with some new species as well) that would be economically valuable to the farmer and also maintain or improve soil quality. Research work has focused upon the search for incremental changes, such as the establishment of new perennial species in suitable niches within the current, unsustainable production systems, that would increase the degree to which conservation and production goals were met by these systems. The project will thus provide farmers with a range of options for making the transition from their current arrangements to more diverse agrosilvopastoral systems. The aim of this work is "to develop a strategy for transition production systems that over time increase the use of perennial plants (grass and legume pastures as well as trees) in cropping systems and in varying landscapes. In doing so, it aims to develop principles for management of hillside landscapes or multifarm systems, to improve the efficiency of the use of the land both in time and space, while increasing the ability to preserve the environment." [CIAT 1994, p106]

The original project plan had also included work on the biological control of pests and diseases, specifically on Integrated Pest Management (IPM), but implementing this in the early stages of the project would not have been practical. As the Project Manager explained, the first task was to test a range of systems in order to identify useful 'prototypes', which could then be planted on a larger scale for more extensive trials. Only at that point would it be sensible to begin work on IPM, for which long-term studies over large areas are required in order to produce reliable results. Before that point was reached, it was not possible to predict which pests were going to be most relevant to the systems that would be selected: while the most important pests for any individual crop were well-known, it was not clear that they would still affect integrated systems including the same crop.

Another consideration was that effective work on IPM requires a considerable commitment from an appropriate specialist. The Project Manager was not in a position to make such demands upon the time of scientists from other Programmes, particularly since this was CIAT's first experiment with inter-Programme working and there could be no guarantee that it would succeed. "We didn't want to put everybody on line until we had finished the preliminary adjustments." Instead, he sought to broaden the range of specialisms involved in the project in a cautious, step-by-step manner. In fact, at a later stage the trials were attacked by a "horrible" insect pest, so an entomologist from the Bean Programme who was an authority on IPM was asked for help. He had not taken part in the PPO, but became involved with the IPP at a time when there was a clear need for his expertise. "He got a student who began a thesis on that particular insect, so in effect he was pulled into collaborating with the IPP, perhaps having less knowledge than the other scientists involved about the whole Project."

Inter-Programme trials

The most visible part of this project is at present a large piece of land (landscape-scale rather than farm-scale) in Pescador which CIAT has hired from the community and uses to conduct a number of researcher-managed trials. Since the unit of analysis is the landscape, rather than the individual farm or plot, these trials include treatments aimed specifically at steep slopes, as well as efforts to find appropriate niches for trees so that they will add value to the system without competing with crops. The trials conducted involve the progressive introduction of a number of new crops into plots that in other respects resemble the 'typical' hillside production system. These new crops are diverse, perennial, deep-rooted species, and so their introduction is expected to increase the sustainability of the system. This hypothesis is tested by monitoring the behaviour of the whole system and (especially) changes in soil properties (chemical, physical, biological and Agronomic); indeed, studies are carried out on changes in nutrient balances and soil mechanics under different types of inter-cropping. The information collected in this way is used to evaluate the consequences of introducing the new species. Separate socio-economic research is investigating possible market opportunities that would enable farmers to earn additional income from the new crops and thus provide the incentives necessary for their cultivation.

By its very nature, this work transcends the cognitive boundaries that divide the work of CIAT's different Programmes, and that separate the different academic disciplines from each other. The work of this Project does not lie within the domain of any single Programme but needs to draw upon the expertise of specialists in the various crops tested, in the chemical, physical and other properties of the soil, and in the social and economic circumstances that may affect farmer responses to these new ideas and the profitability of such responses. The implications of this requirement, and the organisational arrangements necessary to satisfy it, will be discussed later in this chapter. First, however, it is necessary to explore the relationship between the objectives of this project and CIAT's strategic mission.

Strategic Significance of 'Prototype Systems'

The trials in Pescador involved constructing complete production systems and studying their performance in a number of dimensions (both bio-physical and socio-economic). At first sight, undertaking this work to develop and test complete systems for hillside agriculture would appear to contradict one of the basic assumptions of the first project described (see above). It is argued that the diversity of the (physical and socio-economic) conditions in which Andean hillside farming occurs means that it is not feasible to develop a single complete system (or even a manageable number of different systems) that would be 'optimal' for this environment. Instead, the task of research is to "identify and improve strategic components of different types of hillside production systems" [CIAT 1994, p123]. Responsibility for combining these components into the multitude of different, location-specific production systems that will eventually emerge rests with farmers.

For these reasons, the definition of 'prototype systems' that had been developed by the Lowlands Programme (as seen in their work in the *llanos*, discussed in Chapter 3) required modification in order to be applicable to the hillsides ecosystem, even though this paradigm was then 'driving' resource management research at CIAT. The reader will recall that research in the *llanos* had concentrated upon the development of effective systems blending new varieties of forage crops with rice, seen as 'best bet' options to increase both the productivity and sustainability of agriculture. These systems were first developed and tested by researchers, then offered to farmers, who could simply decide whether or not to adopt:

there was no suggestion that the systems investigated were seen as representing a range of different systems (leaving scope for farmer choices).

The IPP Project Manager argued that since the Tropical Lowlands Programme had pioneered work with prototype systems this experience had provided an important inspiration for the IPP. However, although the trials in Pescador are also described as being experiments with 'prototype' systems, each of these is now seen as *representing* a large number of actual production systems. The Project Manager explained that he saw a prototype as being a working model that, once it has been given the characteristics that are desired, can then serve as the basis for many different versions, each of which exhibit the same desirable features. Further: so that the results of these trials would be generally applicable rather than location-specific, the analysis is based upon the concept of plant *types*. This means that each crop planted in these trials is seen as representing a range of plants with similar characteristics (for example, beans serve to represent all short-term shallow-rooted plants). It follows that the results of each 'prototype system' trial will remain valid if any (or all) of the crops tested are replaced by other plants with similar characteristics. A wide range of choices would thus remain to be made by any farmer responding to the results of these trials.⁶⁶

The Project Manager stressed that these trials of prototype systems are designed, not just to develop a solution that works (as would be the case for action-research) but to understand *why* it works (i.e. to elucidate and document the underlying principles).⁶⁷ He stressed that the objective of the IPP is not to generate technology but to generate knowledge that can then be used to develop technologies. Indeed, the generation of technologies based on this knowledge would depend upon linkages with other organisations active in agricultural innovation, particularly the NARS. His view is thus consistent with

⁶⁶The concept of 'prototype systems', as understood by the IPP, may be compared with that of *robust design*, which is found in the literature on industrial innovation. Thus Rothwell [1992, p229] discusses *robust designs*, which he describes as designs for "products that are flexible with respect to changing market requirements ... [designs] which are capable of evolving into a significant *design family of variants* satisfying a broad range of user segments, i.e. the designs are robust with respect to evolving user requirements and the development of market segmentation".

⁶⁷For example, while it is known that the banana-coffee intercrop is grown successfully in the hillsides ecosystem, no explanation is available for the success of this system. In particular, little is known about the distribution of roots when these two deep-rooted perennials are grown together. Such knowledge, Dr Sanz believed, would make it possible to design other systems using these plants as components, and to suggest effective alternatives to coffee (which had ceased to be a profitable crop).

the variant of the 'linear' model of innovation that is embodied in the formal organisation of the CG System, as discussed in Chapter 2.

The work of the IPP therefore involves obtaining far more information than would be required by an 'action-research' project. Studies are carried out on changes in nutrient balances and soil mechanics under different types of inter-cropping. The systems are simple and cover large areas, so there is scope for modification within them (more detailed 'sub-experiments'). Although these experiments are local, they give broad scope for many uses of the land because their results have a broad range of potential applications. At a later stage, it will be possible to move these experiments to other parts of the watershed with different conditions, then to other watersheds. The objective of this work is to derive principles that will be applicable elsewhere, and so the researchers involved need to think in terms of systemic properties that would apply across a range of locations.

This emphasis on the quest for underlying strategic principles is clearly present in the description of the project presented to a team of external evaluators acting on behalf of donors [CIAT 1994a]. This document argues that the applied research on steep-slope agriculture that has been performed up to now is mainly experimental work that is specific to a single site or problem, while "there is a general deficiency of attempts to derive principles with strategic validity". Therefore, "long-term strategic research is needed to provide principles for the development of 'transition' systems". The document goes on to argue that "an important strategic concept to be explored is the possibility [of developing] prototype 'transition' systems which involve more than one farmer in managing soil, water and vegetation at the 'landscape' or multi-farm scale", noting that "appropriate land management in the hillsides will very likely require collective action by numbers of small farm units or plot owners" and that these people often occupy parts of landscapes that include communal property (such as forests, grazing and water resources). It does not discuss the need for community organisation ("social technology") to facilitate such collective action: indeed, this dimension does not appear to be present in the Inter-Programme Project itself. The need for this dimension was reiterated verbally by the Leader of the Hillsides Programme in the words: "Most of the value of the Systems trial will only be realised if it is linked to the work on small farmer participation".

This Leader expressed a complementary view of the purpose of developing “prototype systems”. For him, the Systems trial was not intended to develop ‘packages’ that can then be diffused as recommendations to farmers:

There is a fundamental belief in this Programme that not only the tuning of recommendations but even the development of the production systems can be done by the farmer. That belief is the whole basis for participatory research: that they in fact can do a whole lot of that research, and develop their own production systems. So we are never in the business of developing recommendations. We are interested in these fundamental issues of what happens if you have [say] continuous shallow-rooted, highly fertilised crops, what this does to the soil quality, as opposed to perennial crops, or a rotation of annual and perennial crops. [And that sort of information about the consequences of farmer decisions can then be fed back to farmers.] And the information from these trials includes far more than just the behaviour of those crops. For example, if you are looking at the leaching of nitrogenous fertilisers and the consequences of this, that incorporates information on the climate. [As similar trials are performed in different environments, it becomes possible to recognise the climatic conditions under which cultivating highly fertilised, shallow-rooted short season crops will lead to serious nitrate leaching, which in turn affects soil acidity and quality. Under other conditions] you can do exactly the same thing without risking that problem.

The Programme Leader responsible for this project thus believed that it would eventually make it possible to forecast, for any given landscape in the hillside ecosystem, the long-run consequences of continuing different sorts of land management. The Project Manager warned, however, that this might only be possible once the principles underlying the relevant processes are understood. At that point, if not earlier, it becomes feasible to discuss the long-term consequences of pursuing different land-use options. Indeed, the Leader stressed that the objective of the Programme is not simply to understand the principles but to allow people to use those principles to re-assess their perceptions of the direction in which their production systems are going:

And that is the final test. The information that we generate will only have value if the decision-maker changes his mind. ... So unless we can see decisions changing at the local level, the research has very limited value. So it breaks down these barriers between Basic, Applied and Adaptive work.

In the light of the different emphases found in these two accounts of the meaning of prototype systems and the reasons for developing them, it is interesting to note that the phrase is not defined in any of the documents produced by the Hillside Programme. Indeed, its Leader remarked that phrases like ‘systems work’, ‘cropping systems’, ‘farming systems’ are understood differently by different people. “I think that the message [of what we are trying to achieve] is not easy to get across. If you gave an exam after most discussions of the Hillside Inter-Programme Systems project, you would get rather a large variation in

the responses [in what people are doing and in the reasons for doing that]. A lot of people think that that work is very site-specific. I don't see it that way at all."

Other people, however, have criticised both of the projects discussed in this chapter for being too site-specific, while CIAT is mandated to undertake strategic research whose results can be applied to a range of situations. The most coherent statement of these criticisms was made in the course of a focus-group discussion with members of the Cassava Programme, who compared their work (for the Cassava Biotechnology Network) with that of Laderas. In both cases, they saw that the assessment of user needs was being emphasised, but felt that the processes for doing this were very different: "What we aim to do is come up with a needs assessment on a *subset* [of the issues], and this subset is called the cassava-based sector ... We took just one crop, but we talk about countries, regions, continents, whatever; Jacqui goes holistic [and] ... talks about anything under the sun, but in a tiny area."

This argument was developed in the following terms:

First she [Jacqui] identified an area, put a fence around it, made an inventory of whoever is working there, sat around the table and started the process of [identifying] what is going on and what needs to be done. And by doing this she has given herself this incredible institutional problem, of all these stakeholders with all these driven agendas, trying to squeeze those into one [activity] that would be agreeable to all, and all marching in the same direction or complementing each other.

An additional difficulty is that "you can't just project [extrapolate] from the little *cuenca* area to the whole of [say] Tanzania or Uganda". Part of the work of the Cassava people was therefore the development of a structure that would enable them to put together the results of a number of different small-area studies (such as that being undertaken by Laderas), even if these results were anecdotal or in different forms. They hoped that in this way they would be able to link "the information gained in these micro-level case studies, the *cuenca* approach work" with the information needs of a globally-oriented Programme. These information needs essentially concern the problems and research opportunities that are relevant to "important pockets of cassava-producing, processing and trading people, which can be scattered over the country or over the whole world".

Constraints to inter-Programme working

The Programme-based Culture

The Inter-Programme Project, by virtue of the problem that it addresses, is critically dependent upon contributions made by people from other Programmes. However, their ability to work in such a cross-Programme manner is constrained by the Programme-based arrangements for staff management and evaluation within which they have to operate, which are not appropriate for a project of this nature. Senior management declined to make special arrangements, apparently because they were not sufficiently committed to this project. Indeed, the status of the Programmes as the basic unit of CIAT's organisation contradicts efforts to work in this manner. As a leading member of the Lowlands Programme explained, until 1992 CIAT had always been four distinct Programmes, "almost four centres in one, where there was little interaction between the Programmes: they all had their separate fiefdoms, which still exist. So there were a lot of walls put up between the Programmes." The effectiveness with which this structure had focused the efforts of different specialists upon single groups of commodities had contributed to the research achievements upon which CIAT's credibility was based, but this record also strengthened resistance to change. Perhaps the greatest resistance came from the Programme leaders "who have driven things here. ... They want to defend their own Programmes and stick to their mandated area" so that demonstrating the impact of their Programmes will be simple.

Given this long-established culture, it is natural that the interests of most CIAT staff lie within the work of their Programmes. That is where all their discussions and planning take place, that (rather than in projects) is where they are accountable for their work, and if they are subject to an annual review it will be a review of their Programme. It follows that their primary commitment is to their own Programme, their primary obligation is to fulfil the work plan agreed with their colleagues and leader within the Programme. Meeting this obligation is the best way to secure for themselves job security and merit-related salary increases.⁶⁸

⁶⁸These points were made by several scientists interviewed in January 1995. In particular, salary increases depend upon the evaluation of their work that is conducted in isolation by their Programme leader.

It follows from this that other tasks, such as work for the Inter-Programme Project, will take second place after work for one's own Programme.⁶⁹ One scientist, discussing the involvement of his colleagues in inter-Programme work, commented that "if things get difficult they will probably shift their focus to their own Programme and just give away the crumbs that are left over. I think that this is what is happening now." The (acting) Leader of Laderas, however, felt that the outcomes had been mixed, that the contributions made to inter-Programme work by different scientists had varied with their individual circumstances. In some cases the arrangement had worked: "Dr A was new and as yet relatively uncommitted, while Dr B works for 120 per cent of the time". However, other people whose time had been promised (two individuals, Drs C and D, were named) were already "tied up with their own work" and so the contributions promised had not been delivered. (A later conversation revealed that by this time Dr C had made a full-time commitment to Laderas, while Dr D, although fully loaded, was making great efforts to deliver the work promised earlier.)

A leading member of the Lowlands Programme described this situation in the following terms: "The same group of people was asked to work in both eco-systems, which naturally would have slowed progress. We were already fully occupied in the savannahs and now we were expected to take on more complex issues in the hillsides, so it was inevitable that progress was going to be slow." He revealed the group's unconscious choice of priorities with the words "the capacity of this group of people to collaborate with the Hillsides Programme was limited by the magnitude of their workload within their own Programme", although he admitted that "there were really no structural pressures to limit their contribution to the Hillsides".

Staff Evaluation

This tendency to give priority to work within one's own Programme is reinforced by the system of evaluation by Programme leader, in conjunction with the fact that the scientists involved in the project continue to be managed by the leaders of their Programmes. This means that the Project Manager has no formal authority to ensure that the work promised is actually delivered, since the people involved are not accountable to him. In particular, he

⁶⁹This point was made explicitly by a senior member of the Cassava Programme.

does not contribute to the process of staff evaluation, which is performed by each scientist's Programme leader, acting alone and (presumably) upon the basis of that scientist's contribution to her/his Programme. Work performed for other Programmes does not contribute to this evaluation. The atmosphere of insecurity resulting from recurrent budget cuts imposes pressures upon staff to secure a favourable evaluation and to demonstrate their value by producing results from their work within the Programme. And even if this problem were resolved, so that the results from work for another Programme could contribute to their evaluation, if the time devoted to this work is less than a certain critical level then no useful results will be obtained, particularly not in the short term. As one scientist explained; "If you know that you will be evaluated in the next budget cut, when the sword will fall on those who have been the least productive in the last year, then you will not put much effort into a side activity that will not contribute to your evaluation."

He also believed that "evaluations by their nature think in the short term" so that this situation imposed pressures on him to produce results in the short term, even at the cost of longer-term activities that he believed were far more important. "If I had a short-term experiment and a long-term experiment, at present I would put all my effort into the short-term experiment, even if I felt that the long-term one was more valuable, because the latter would not give me anything in the short run. ...[And] I think that a lot of people feel the same need for short-term productivity after four cycles of budget cuts." As a result, his entire research strategy was dominated by this objective, rather than by his professional understanding of how to perform relevant, high-quality research work: "I focus on grabbing something which gives me results in say a year, which means that I can't set up an experiment of my own but have to take samples from existing experiments", even though the nature of his specialism meant that "I should go for long-term experiments" because the processes involved take place "very slowly". More generally, "you have to do long-term experiments, particularly in Natural Resource work. The major activity of the Lowlands Programme is an experiment planned to last for two four-year cycles (eight years). The Inter-Programme Project is also planned for eight to ten years. So in the very short run, you will not show anything [from this sort of work]."

These pressures to produce results in the short term thus subvert standards of scientific excellence (indeed compromise the professional integrity of the researchers who are

subjected to them) and undermine efforts to perform meaningful Resource Management research. They are particularly damaging to new long-term experiments like the Inter-Programme Project. This experiment will start to give results after two or three years, when there have been a few cycles of crops so that differences in fertility or erosion begin to be apparent. So at that time people may be able to get valuable data, but at this stage the only outputs that they could show from it are plans and monitoring, and "that doesn't give you a good evaluation". More generally, the system of management and evaluation operates to inhibit cross-Programme work, even though scientists themselves, rather than managers or Programme leaders, decide how to allocate their time and which tasks they will undertake. This outcome was not affected by the overt stance of the Programme leaders, who neither encouraged nor resisted participation in the Inter-Programme Project.

The need for a high degree of interaction

Other difficulties arise from the nature of the Hillside Inter-Programme Systems trial. The project is concerned with systems rather than isolated components (so that interactions between different components are important), while the variables that it seeks to optimise (soil quality, water management and labour productivity) are emergent properties of the entire system, dependent not only upon each of the system's components but also upon the interactions between these components and their degree of complementarity. Not only must such research draw upon the expertise of specialists in the different crops tested, in the various properties of the soil and in the behaviour of farmers and other users of the watershed, but the inter-dependent nature of the problems investigated means that a high degree of cooperation between the specialists involved is essential if progress is to be made. Achieving such cooperation is unlikely to be possible unless conscious efforts are invested in team-building activities, but these would probably be resisted by scientists who tend to regard meetings as a waste of time, while the time available is in any case severely constrained by the factors outlined above.

The reasons for this resistance to attending meetings were clarified by another Senior Scientist: "People are sick of discussions because for six years now CIAT has been buffeted by leadership changes and each new leadership set has been trying to cope with the rapidly changing external environment." Each of these internal and external changes meant that

the Centre's staff had to leave their laboratories to prepare a revised set of plans. The acute frustration that has resulted from this endless planning process, following recurrent budget reductions, is clear from the words of a former Programme Leader: "Every time we re-planned something, by the time we had re-planned it we came out with less money. I think that that has worked against us, because now people will ask what we have done in the last three years, and the answer is that we have written plans ... now we are into the stage where what we are doing is writing project proposals: nobody is actually doing anything. We need to break that cycle and actually get some work done, then the money will start coming in, but it has been very difficult." These experiences may explain why few CIAT scientists are able to feel great enthusiasm for attending yet more planning meetings. In particular, the scientists contributing to the Inter-Programme Project regularly meet Dr Sanz for 'one to one' discussions of their individual contributions, but have not met as a group since the conclusion of the PPO session.

There is, however, a real need for the researchers involved in the Inter-Programme Project to invest time and effort in understanding each other and their joint work. Indeed, this need is increased dramatically by the project's specific character. Many of the concepts underlying this project, as well as the philosophical framework in which they are embedded, are not familiar to most agricultural scientists. This leads to difficulties in appreciating the overall objectives of the project and the significance of each person's contribution to these objectives. And these difficulties are compounded by the innovative *approach* followed by the Hillsides Programme, described by a soil scientist as "soils or agronomic research embedded in socio-economic research. ... The socio-economic work was primary and the need for agronomic/soils work developed from that."

This soil scientist felt that the strong linkage that he described was one of the strengths of Hillsides, but realised that it increased the difficulty of collaboration with other Programmes. If members of other Programmes are to understand the approach of the Hillsides Programme they need to experience the interaction between its bio-physical and socio-economic groups and so they would have to be involved in some discussions of the socio-economic work. However, this would run counter to the usual approach of these people, which is to allow someone else to define the problem and only then to work to solve it. As a leading member of the Lowlands Programme explained, their intention had

been that the group of people working on soil-plant relations within the Lowlands Programme would “eventually work on the bio-physical problems of the hillsides, *once the socio-economic problems of this ecosystem were well-characterised*. At this stage there would be a need for work on the bio-physical aspects. [In the short term] the group felt that the problems in the hillsides had not been identified as thoroughly as those in the savannahs. And that is still the case: we are still a little anxious about exactly what we should be looking at in the hillsides.” He did concede that the members of this group could have a role in identifying problems that they could address, but also explained why there would be resistance to assuming this role: “It may all be there: we just haven’t sat down and worked through it sufficiently together. But that would mean taking people away from the laboratory, and they are already sick of meetings: they want to get on and do some work, so imposing more discussion would mean a loss of goodwill.”

For these reasons, according to the soil scientist quoted above, the interaction between the members of the Hillsides and Lowlands Programmes had been limited. He noted that there had never been a joint meeting of the soils people from the two Programmes “to plan, to discuss the progress of the experiment or decide its future direction”. As a result, the soil scientists in the Lowlands Programme did not appreciate the way in which the soils work in the IPP had developed from socio-economic research and so could not see the overall strategy pursued. Indeed, they had little idea what the socio-economic group did, since the Hillside’s approach was very different from the working practice with which they were familiar. Therefore, they worked in the hillsides as if it were just a site for taking soil samples. He recalled a meeting with these people in which “there were quite a few negative remarks towards Hillsides, towards the experiment which [they said] was poorly focused. They were taking measurements in it but they did not know why — basically reflecting that it is a sampling site for them but they don’t feel involved, they don’t feel the philosophy behind it. They don’t clearly see the aim of it, where it should go, what their role is, why they are expected to do certain things (which they don’t do), all clearly reflecting a low level of involvement.”

A broader view of the varying levels of participation in the IPP was provided by Dr Sanz, the project manager. He observed that the scientists involved in the IPP include both those involved only in their particular area of specialised interest and also some who are interested

in addressing more general problems and in seeing the place of their specialism within the system as a whole. He mentioned a particular soil physicist as an example of the latter, explaining that he was involved in appraising soil physical properties in all of the contrasting treatments (or systems) included within the IPP. "So he is almost as involved as I am: he is involved only in Soil Physics, but he is involved with the overall project and not just with one specific aspect." On the other hand, he felt that the Rice people, who remain within their role as experts on a particular aspect, provided an example of the former. They were "only involved with the rice part of the project and were not interested in the cassava or soil biology parts. Some of the Rice people could get involved in more general parts of the project, but it hasn't happened yet." For example, a specialist in weed dynamics had collaborated in the Savannahs. In the future he might get involved in studying weed dynamics [in the Hillsides] and that would imply not just upland rice systems but also comparing those with other systems involving other plant types. "This reflects CIAT, and the transition which it is experiencing. Some people have already made the jump and are dealing with the global situation, even if they are only working directly with a little bit of it they look at it globally. Others are only worried about their little bit."

A greater level of involvement, then, is necessary if the Project is to achieve its objectives. This can only be obtained if the collaborating scientists make a larger investment of their time, particularly in activities peripheral to their specific tasks. As one scientist pointed out, this would not be a problem for someone who worked entirely for Hillsides, who would be happy to spend ten or twenty per cent of that time on interaction with the socio-economic group. But somebody who is only supposed to put ten or twenty per cent of their time into doing bio-physical work for a project based in another Programme will not be willing to spend half of that limited time on hearing about the work of other people from other disciplines, because then s/he would not do anything else. "If I had only a month available to do [bio-physical] research in the Hillsides I would not spend half of that in meetings with socio-economists and in deciding the future of the experiment. I would probably just do my sampling." He felt that this problem could not be solved as long as people gave only a few per cent of their time to Hillsides: "I think that you can only get a better balance by putting those people into Hillsides not for twenty per cent but for fifty per cent" of their time, since otherwise finding out about the work of other disciplines "is just not worthwhile".

Resistance to Team Working

Another obstacle to such collaboration is the desire felt by many individual researchers to decide for themselves how their research will be designed and run. Dr Sanz noted that people were still very possessive about their work, and that even within the IPP they still felt that "these are my trials". Such attitudes often accompanied a strong resistance to allowing people from different cognitive backgrounds to influence their research practice. (Implicit in this is a resistance to new research approaches.) These points were made most explicitly by a senior member of the Cassava Programme (and a vocal critic of the IPP), as follows;

I want to be sure that I see part of my philosophy as a researcher reflected in this project. If I don't see this, I feel that it is not a very attractive [activity in which to invest time, energy and dedication. But achieving this is not easy when so many people are brought together in a project. It is likely that everyone will want something different, so there will be a whole series of compromises. The final project that results will seem like something] with too much water in the solution, and no flavour. [I think that this is something that we have to learn, because most of our scientists have been mainly doing research by themselves, but we have to learn how to negotiate to find out what we can do together without losing our identities as researchers] and without being fed up by some social scientists who don't understand anything about soils, and apparently because of this nobody is interested in this issue, which they consider of minor importance.

He stressed that this process of learning how to work together would have to resolve the question of the ownership of intellectual property resulting from such a collective enterprise, and the way in which the credit for results obtained would be shared. At the same time, he argued that since each Programme has developed its own methodology, and these are often incompatible, there is a need to agree on common methods and terminology for the whole project and to agree the objectives of each trial within it. Resolving these issues would require a willingness to spend more time in joint planning activities, and the presence of a skilled facilitator who could ensure that the time was used constructively.

As we have seen, the original rationale for the Inter-Programme Project was based on radical ideas about the relationship between research and its context. The actual design of this project, however, was strongly influenced by CIAT's earlier experience of developing Rice-Pastures, so that the 'pipeline'-type assumptions upon which that earlier work was predicated are still embodied in the Inter-Programme Project. Furthermore, a range of factors, rooted in CIAT's organisational culture and power structures, limited both the extent to which collaborating scientists could contribute to the project and the quality of their involvement in it. These factors thus limited the scope offered by the project for

collaborating scientists from different cognitive backgrounds to come to appreciate each others' perspectives. As a result, the project design exhibited a certain rigidity: in the absence of effective discussions between its various participants, there was limited scope for them to appreciate its overall objectives and the significance of their own contributions, nor for the definition of the project to evolve to reflect the needs of the watershed.

Linkages between the two Projects

Ultimately, linkages between the two projects are essential for most of their value to be realised. On the one hand, the Watershed User Associations Project is developing and applying a form of 'social technology' in order to institutionalise demand for the new technologies that will be necessary to implement whatever 'management plan' emerges from negotiations among the project's clients. Intimate linkages with possible sources of the technologies required would therefore contribute significantly to the long-term success of this work. In the absence of such linkages, it risks generating expectations that it cannot fulfil.

On the other hand, the fundamental objective of the Inter-Programme Project is the discovery of technological and scientific principles that may be applied to meet the demand articulated by the first project. The outputs of the IPP should thus enable clients to implement strategies to capture benefits that may be (and often are perceived to be) external to the individual. These strategies are therefore rational at 'landscape' scale rather than at the level of the individual decision-maker, while their implementation may require concerted action by a number of stakeholders. It follows that functioning community organisations of the type being developed by the Watershed User Associations Project are necessary before the outputs of the IPP can be useful. In the absence of links with such 'platforms' for making collective resource-management decisions, the IPP would risk being irrelevant.

A set of organisational linkages between the two projects are in place, so that information can be exchanged. Strictly speaking, the IPP is a CIPASLA project and is ultimately the responsibility of CIPASLA's coordinator. Indeed, the IPP uses CIPASLA's resources (one of its workers is paid by CIPASLA); at the same time, CIAT puts money into CIPASLA.

The members of CIPASLA made a significant (albeit indirect) contribution to the choice of objectives for the IPP, and have been able to use it to support their own projects.

However, demand is not articulated sufficiently strongly for these linkages to be effective: the process of enabling communities to diagnose their problems is still at an early stage, while “ideas about being demand-driven are poorly understood at CIAT” [Senior Scientist].

The first possible linkage between the two projects was the choice of objectives for the IPP. As discussed above (see ‘Planning the Inter-Programme Project’ page 201), the CIPASLA planning meeting had provided the “general objective” for the PPO in which the IPP was planned. However, the majority of the participants in this PPO had been invited to attend because of their experience in developing ‘prototype systems’ for the *llanos*, a paradigm (essentially cropping systems work) that was still guiding NRM research at CIAT. It was natural, then, for the PPO to assume that the problem to be addressed was “the need for more productive or sustainable cropping systems” and to decide immediately to jump “right into the work on prototype systems”. The result of this process was a project design that reflected the assumptions and experience of those who had helped to plan it. In particular, the form of the Inter-Programme Systems trials reflected the experience gained in the savannahs and the large-farm paradigm derived from the old Pastures Programme. Thus, as a hillsides specialist pointed out, the IPP is a display of ‘best practice’ from the Lowlands and other Programmes at CIAT, and does not use many of the insights of local farmers. For example, although the CIATs in Pescador have experimented with peas, raspberries, beans, and quick-maturing maize, the varieties that they preferred have not been included in the IPP Systems trial; ultimately because there was not enough interaction between farmers and scientists at the time the trials were planned.

A second linkage is the use made by the IPP of information obtained from the earlier project (Organising Watershed User Associations). As discussed above (see page 177), the members of this project have (i) classified local farmers by level of well-being, (ii) held structured discussions with members of each group to elicit the different production and resource management strategies followed by the different types of farmer. The IPP Project Manager explained that this work has yielded information about farmer decision-making that informs the IPP’s efforts to “tailor” technological options for different types of farmer. (For example, those in the lowest well-being group cannot afford purchased inputs and so

will only respond to options that do not require these.) However, technological demands upon the IPP have not been strongly articulated, while only limited interaction takes place between scientists and community members. On the whole, therefore, while the experience of the IPP may be leading the scientists involved to question many of their assumptions, this is a very slow process. The hope of the Hillside specialists is that this process of experiential learning will continue with increasing momentum. Then, as this questioning takes place, as new ideas about the community's role in innovation are found to be helpful, so the IPP will itself evolve so that it will eventually become capable of achieving its original objectives.

Collaborative projects, developed and implemented jointly by the IPP and by the member-organisations of CIPASLA, would represent a third linkage between the two. At the time of writing, however, the only example of close collaboration was provided by the dairy project. This project resulted from the efforts made jointly by CIPASLA and by CIAT's marketing/economics specialists to identify new market opportunities for products from the *cuenca*. One such opportunity is milk production, although this can only be realised once a reliable supply of a constant volume can be provided. CIPASLA (specifically one of its members, a semi-official body called SENA, for *Servicio Nacional de Aprendizaje* or National Training Service) is therefore starting a dairy cattle project in order to equip the farmers of the *cuenca* to meet the demands of the market. The IPP Project Manager explained that improved technology will be required for this, particularly if cattle production is to increase without exacerbating the problem of erosion. On the whole (with some honourable exceptions) dairy farmers in the region use what are called 'naturalised pastures' such as *malinis*. These are not the most efficient means of production and often suffer from secondary erosion, caused by cattle grazing these particular species [of forage crops] that are not very resistant to the stamping of the cattle.

The Inter-Programme Project is well placed to respond to this need for improved technology. It is therefore trying out different types of pasture, with cattle coming into those pastures. One such system is the association of *brachiaria* with legumes; another is planting leguminous trees on steep slopes, so that the trees act as erosion barriers and also

as 'cut and carry' pastures whose produce is fed to animals that are kept in stables nearby.⁷⁰ The members of CIPASLA may use the results of these experiments, together with other ideas (their own, or from local farmers) to start projects in response to market opportunities. Thus, by the end of 1995, SENA had brought about four groups of farmers involved in their cattle project to Pescador so that they could see the trials of new pasture technologies; these visits included small training courses, followed by sessions of practical work in the field. Several of these farmers took seeds for the new forage plants back with them so that they could try them out on their own farms.

In this way, as its Manager explained, the IPP acts to generate practical knowledge that CIPASLA can use. It thus functions as a research arm of CIPASLA, creating systems (or prototype combinations of components) that the latter can use. "At the same time we are addressing more basic research questions concerning the sustainability of those systems, what is happening to the soil in the long term, what is happening to the vegetation in general, the properties of the system. Thus, we are not only serving CIPASLA's needs but are also generating knowledge of basic principles from which we will be able to extrapolate across to other watersheds. That is our ultimate aim, so we do not concentrate fully on the watershed where we are working or on CIPASLA's needs, but in general on the Hillside ecosystem." CIPASLA, then, is a user of the IPP, which pursues a range of objectives that includes, among others, performing research for the former.

Other members of CIPASLA are also users of the IPP, although none of them collaborate as closely as does SENA. A Laderas scientist noted that these entities were not working directly with the IPP, and expressed disappointment at the shallowness of this collaboration: "there does not exist a stronger or more solid [shared] work, as could have existed in our dreams. That has not been implemented, but I think that it would be feasible because a stronger link would suit us as much as it suits them." Despite these reservations, he affirmed that these entities, like SENA, have brought groups of farmers to the trial site to learn about the new technologies and to take part in discussions and training sessions conducted by technicians from the CIPASLA member. These visits did not include formal farmer evaluations of the new technologies: a Laderas scientist explained that the

⁷⁰SENA contributed to this work by collaborating in the construction of corrals to hold the cattle.

technicians had not collected or recorded their views in a systematic fashion. He felt, however, that these visits had yielded valuable information about the farmers' views of the advantages and disadvantages of the technology that they were seeing. He acknowledged that these views, especially what the farmers saw as the negative aspects of the technology, were "aspects that we must take into account".

He recalled that some good ideas had come from the farmers who took part in these visits. For example, one such group had been brought there by UMATA, whose main interest was in soil conservation and in systems that would promote this goal. While many such systems rely on fixed erosion barriers to retain the soil, UMATA's clients had said that this would not be convenient for them because the barriers would obstruct their oxen and so make ploughing difficult. However, some of these farmers looked closely at the trials of rice within the IPP (rice is not normally grown in the Andean hillsides) and realised that it could be used as a *temporary* living barrier. The Laderas scientist agreed that since the rice had developed well, it could be sown as a living barrier and give very good soil conservation. In sum: "It is a very good idea that came from the farmers themselves. We have not tried it yet but we intend to implement it later."

However, he was concerned that very little was known about how (if at all) the technologies from the IPP were being applied on the farms of those who had visited the trial site. "We should carry out a follow-up of the people who came [to the project site], in order to see what they have applied or adapted. It is very important for us to know that. That would give us feedback on which technologies they have chosen, how they are applying the technologies and how they have adapted them to suit their conditions. At the moment we just do not know which of the technologies have been taken to the farms."

A fourth possible linkage is provided by the efforts made to bring 'well-being' groups to observe the IPP Systems trial. The reader will recall that the first project (Organising Watershed User Associations) involved forming groups, each of which was composed of people who enjoyed similar levels of well-being and lived or worked in the same zone of the *cuenca*. The intention was that these groups, usually of people who are already involved with CIPASLA's projects, would visit the IPP site and respond to the trials that they see there. The IPP researchers would thus learn the farmers' opinions about what they were

developing. Their hope was that the farmers would take ideas and possibly germplasm back with them, in order to experiment with these treatments (or other practices based on them) on their own land. The IPP would then have supported this, perhaps carrying out experiments with them.

However, implementation of these plans revealed a number of difficulties. The CIAT researchers decided that in the first instance they would make arrangements for groups from the highest level of the watershed to visit the trial site. The stated reason for this decision was that the upper level is mainly inhabited by indigenous people, who are generally poorer than the inhabitants of the lower levels. Up to that point these people had been relatively neglected by CIAT, and the research team felt that they were under pressure to redress the balance. An additional factor, discussed on page 181 above, was that CIPASLA (of which CIAT is a member) needed to effect tangible improvements in the quality of life in the upper zone of the watershed, in order to reward the people there for their efforts to protect water sources.

The first difficulty experienced by the research team lay in the formation of well-being groups. Together with the *cabildo* (indigenous political authority) they did succeed in forming one group: however, as a Laderas scientist explained, "when we tried to form other groups, no-one came. We could not form the groups for many other reasons, but we could not get a sufficient number of people to take to the trial site." Only one group, then participated in these visits: this was composed of people from El Oriente, one of the *veredas* in the upper level of the watershed. All of the members of this group were indigenous, and fell into either the lowest or the intermediate well-being categories. By the end of 1995, they had made two visits to the trial site.

The discussions that followed these visits made it clear that the visitors did not see the technologies on display as offering solutions to the needs that they felt. The Laderas scientist explained that their main concern was to find ways of producing enough food for their families to survive, and so "they could not think about sophisticated systems when they still did not have enough to eat". Their main interest was in mono-culture of basic food crops such as beans, maize, and above all cassava. His "supposition" was that "what is basically produced in the upper zone is cassava ... and a little traditional maize and beans.

It is much simpler to grow these crops as monocultures than as associations of different species." Nor did he believe that the IPP's work on forages was relevant to them, because they had "no money to buy animals that could feed from the pastures there". Instead, their immediate need was for faster-maturing varieties of their food crops, such as those included within the IPP.

The Laderas staff therefore considered offering them the germplasm for the quick-maturing varieties that were included in the IPP trial. They hoped that if they could first establish that these component technologies would work in that environment, they would then be able to work with the farmers to construct complete systems using these components. They knew, however, that the highest level of the watershed was an environment very different from that of the IPP, and that the performance of crop varieties in the two environments might be very different. As well as this uncertainty about the effects of altitude upon the performance of their varieties, they did not know how these plants would respond to the agronomic practices of the farmers from the highest level. Trials were therefore necessary. As the Laderas scientist recalled: "They initially wanted to sow maize and cassava. We sowed maize, but using their methods (basically with zero technology). The maizes that we have did not work: in the trial they failed and all the plants died from lack of fertiliser, since our varieties cannot resist low levels of fertiliser."

The components being tested in the IPP systems trial were not, therefore, appropriate for use in the upper level of the watershed. Nor were the people of this region ready to begin constructing their own systems, using their own varieties but applying the principles underlying the prototype systems trial. As a Laderas sociologist explained, this was because a multi-crop system requires a more continuous input of labour than monoculture, since the different crops within an association require attention at different times. Now the Paez, one of the two indigenous peoples living in the region, are semi-nomadic and are accustomed to leaving the area to seek employment at the times when their crop does not require attention. They would therefore need to change their whole pattern of living if they were to cultivate transition systems successfully. Clearly, they are not yet ready to make such an adjustment.

Conclusion

This chapter has analysed the manner in which Laderas' research strategy was actually implemented. This strategy (considered in the previous chapter) was aimed at the construction of a working model of participatory research and development for sustainable agriculture, a model that would develop systems of land management that would sustain and regenerate the natural resource base [CIAT 1993]. It therefore involved both the development of *institutions* through which demand for new technology could be expressed by its prospective users, and the development of technology to satisfy that demand. These two tasks, relating to the demand for, and supply of, technology, have been undertaken as distinct projects by two different groups of researchers. This arrangement, despite its obvious practical advantages, has deprived those developing the technology of the insights into the needs of their end-users that might have been gained had both projects been undertaken by a single team.

The primary task faced by the first of these projects was the formation of a community-based Watershed Users' Association. This was to be a political structure, within which the multitude of interests present in the *cuenca* were to find expression. However, political structures are vulnerable to capture by elite groups and may thus lose their capacity to serve as a forum for the expression of dissenting views. Such an outcome may be averted by the determined exercise of countervailing power, but only if some actor is able and willing to do so. This condition is unlikely to be satisfied if the powerful actor(s) most closely associated with the political structure in question lack the capacity for coherent decision-making, nor if they enjoy an overly close relationship with the elite group concerned. Indeed, if powerful bodies external to the political structure concerned act to define its *meaning*, the capacity of its participants to articulate their own definitions may well be impaired. The following points, drawn from the account given earlier in the chapter, serve to support this analysis.

The Watershed Users' Association was intended to formulate a research agenda that represented the aspirations of all stakeholders in the watershed. The existence of such an organisation, open to all the different types of stakeholder present in the communities served, was seen as a necessary pre-condition for the development of community-based capacities to articulate demands for research. Indeed, since new technologies were

intended to be developed in response to demand articulated by the Association, the development of this organisation and its openness to all relevant stakeholders were fundamental to the entire strategy. The manner in which the Association was formed, and the structures upon which it rested, help to explain why it was unable to represent the interests of a significant group of stakeholders.

Laderas began its work by forming, not the planned Watershed Users' Association, but a consortium of development agencies active in the relevant watershed. Subsequent work, including the formation of the Association, was therefore shared with the other members of the consortium (CIPASLA). The decision to work in this way was perhaps surprising: while there was a need for the agencies to coordinate their activities (since the work of each may be affected by the actions of the others), coordination may mean information or resource sharing as well as joint action [Honadle and Cooper 1989]. Indeed, Thompson and Warburton [1985] argue that a coordinated inter-agency initiative is not an appropriate response to problems characterised by a high degree of uncertainty — as are virtually all natural resource management problems. Coordination and integration, for these authors, “inevitably reduce diversity, redundancy, duplication and overlap”, thus limiting the scope for “learning, flexibility and opportunistic adaptation” [*ibid* p31]. Instead, they advocate “an approach by way of plural institutions and divergent perceptions” so that when no consensus exists upon the correct perspective, the problem may be seen from more than one perspective [*ibid* p33]. Whatever the merits of arguments such as these, pressures from beyond Laderas (CIAT's Centre-level policies and donor preferences) dictated that a consortium approach be adopted.

CIPASLA, the consortium whose formation had been catalysed by Laderas, was susceptible to manipulation by a subset of its clients. A group of traditional leaders from one of the client communities played an active part in the process by which CIPASLA set its agenda. They ensured that this agenda reflected their own objective of protecting water sources, as well as the established priorities of the agencies that were now members of CIPASLA. They also took part in CIPASLA's work of organising the Watershed Users' Association, FEBESURCA, which was therefore presented to its prospective members as an organisation whose purpose was the protection of the water sources in the upper level of the *cuenca*. This agenda was not a priority for certain stakeholders, who therefore declined

to participate in the Federation. Other stakeholders were excluded in a more direct fashion by the same group of traditional leaders, who organised elections to FEBESURCA's committee and therefore almost certainly influenced the outcomes. Such exclusion of dissenting stakeholders was aggravated by the fact that FEBESURCA was a federation of existing groups, each of which could be represented on the Federation's committee. These groups were not representative of all stakeholders but were biased against representation from the lowest well-being category households. Only a certain section of the multiple interests relating to the management of the Cabuyal watershed were thus represented in the Federation [Ravnborg and Ashby, 1995]. As a result, FEBESURCA simply reproduced the established power structure of the *cuenca*, while the interests of other groups were excluded.

This outcome was all but fatal for Laderas' strategy, since it meant that the Federation was unable to evolve as an effective mechanism for channelling demand from a wide range of stakeholders. In particular, certain important conflicts over natural resource use were excluded from its jurisdiction since it did not represent some of the interest groups involved. This outcome might, perhaps, have been averted had Laderas exercised greater control over the selection of committee members for the Federation and thus ensured that a wider range of interests was represented. Such efforts would, however, have displeased the group of leaders who wished to ensure that FEBESURCA would act to advance their own agenda. While Laderas might have been willing to engage in such a confrontation, the other members of CIPASLA were not: nor would they support subsequent efforts to redress the imbalance of power within the Federation. The decision to collaborate with other agencies in developing FEBESURCA thus led directly to elite domination of the Federation.

Another unfortunate consequence of the decision to form a consortium and agree an agenda with its members before developing the Federation was the imbalance that was present between CIPASLA and FEBESURCA. CIPASLA already had an agenda, so it was natural for FEBESURCA, as an organisation of CIPASLA's beneficiaries, to follow this agenda rather than to challenge it. This tendency was strengthened by the submissive attitude that the members of the Federation's committee adopted towards the professionals present (staff members of the agencies belonging to CIPASLA) as well as to the community leaders. This

rendered them incapable of expressing dissent, so that the views of their constituents could not be represented effectively.

These weaknesses of the Federation meant that it was not able to exert demand for new technology. In the absence of such demand, the direction of the Inter-Programme Project was determined by CIAT's cultural and organisational characteristics. Since these characteristics of the Centre had been derived from the 'pipeline' model, they acted to modify the Inter-Programme Project so that it conformed more to the 'pipeline' than to the 'fifth generation' model. This was already apparent in the 'planning by objectives' (PPO) session with which the implementation of the Inter-Programme Project began. As the plans made in that session were progressively implemented, it became increasingly apparent that the development of this project was constrained by several of CIAT's structural characteristics. Several such factors limited the capacity of the IPP to investigate questions whose dimensions transcended the boundaries between Programmes: these included the Programme-based arrangements for staff management and evaluation; the manner in which most CIAT scientists defined (and limited) their role; and, above all, the lack of group facilitation skills or other means of enabling scientists to appreciate the relationship of their own and each other's work to the wider objectives of a complex inter-disciplinary project. The significance of these factors will be considered further in the following chapter.

Over the same period, however, it became apparent that negotiations between developers and users of new technology were taking place through a range of unplanned mechanisms. Thus, some of CIAT's social scientists had, through their involvement in the development of CIPASLA and FEBESURCA, gained considerable insight into the determinants of farmer decision-making. This insight into the needs of end-users had informed their discussions with scientists collaborating with the IPP and had thus influenced some of the technical choices that had been made. Again, the IPP had collaborated with a member-agency of CIPASLA to develop technology appropriate for the dairy project run by the latter. Other member-agencies of CIPASLA had brought groups of farmers to visit the IPP trial site and had recorded helpful ideas and constructive criticisms made by the farmers: these had been taken seriously by the scientists involved. Real progress was thus being made towards realising some of the fundamental objectives of the Hillsides Programme.

Chapter 6: Conclusions

The conclusions from this thesis relate, broadly, to three distinct themes. The first of these is a methodological point: the 'soft systems' concepts of *hierarchy* and *emergence* have been used to establish causal relations between developments at different levels of the system considered, and has thus been found to be useful in understanding real phenomena. The second theme concerns the limits to the validity of the 'pipeline' theory of innovation, and the kinds of problems that may be addressed effectively by innovation-oriented institutions that are predicated upon this theory. While this theme is essentially static, the third theme is dynamic: the changes that are necessary if an institution that has been predicated upon the 'pipeline' model is to practice fifth-generation innovation.

Emergence

This thesis has presented four linked narratives. The first chapter examined changes in the scholarly community's understanding of innovation; the second discussed the structure and performance of a set of research institutions; while the third chapter outlined the history of CIAT, a single member of the CG System. The final part, consisting of the fourth and fifth chapters, described the planning and implementation of a single piece of research, one of many conducted by CIAT. These narratives, then, unfolded at different *levels*, but are intimately connected to each other. The ideas discussed in the first part guided the construction of institutions, such as those considered in the remainder of the thesis, whose explicit purpose was to generate a stream of innovations. The experience of such institutions has in turn contributed to revising the manner in which the process of innovation (including its institutional locus) has been conceptualised.

The remainder of the thesis considered three systems that were nested inside each other. The CG System (Chapter 2) thus includes many International Agricultural Research Centres, one of which is CIAT (Chapter 3). CIAT in turn is composed of a number of Programmes, including Laderas (part 4). And the events that unfolded at these different levels were linked by a web of causal relationships: events at one level had profound and often surprising effects at other levels. This situation corresponds to the more general observation that the properties of a system may not be readily deduced from a study of its

components in isolation since, although the behaviour of the system is related to that of its components, the relationship is not straightforward [Conway 1993]. This phenomenon is known as *emergence*, and arises because the various components affect each other. My first conclusion, then, is that the concept of *emergence* is useful in understanding real phenomena. The discussion that follows should serve to illustrate this assertion.

Institutions for Innovation

The first chapter presented a critical review of the 'pipeline' model of innovation, and noted, on the basis of a considerable body of empirical evidence, that (i) many examples of effective innovative activity had *not* been organised in accordance with the model's prescriptions; (ii) there were many cases where the innovative performance of institutions organised in harmony with the dictates of the linear model was apparently worse than could reasonably have been expected. The second chapter then considered a set of institutions — the CG system — and argued that it had been predicated upon the 'pipeline' model: indeed, that it exemplified this approach to innovation. From this, it follows that not only the structure of the CG System, but the entire experience of the 'Green Revolution', may usefully be interpreted as a practical test of the efficacy of the prescriptions of the 'pipeline' model.

The results of this practical test were mixed. Both the success of the CG Centres in achieving their well-defined original goal (that of increasing aggregate yield), and their relative failure in confronting more complex, poorly-defined problems (such as the degradation of the natural resource base and the inadequate livelihoods provided by low-resource agriculture), were seen as reflecting the strengths and weaknesses of the 'pipeline' approach to innovation. In particular, CIAT's 'pipeline'-type mission to perform strategic research conflicted with the regional (as opposed to commodity) mandate with which it had been founded. While the 'regional mandate' obliged the Centre to consider complex problems involving multiple crops, such work was excluded by the definition of 'strategic' research accepted within the CGIAR. In order to manage this contradiction, CIAT effectively divided itself into four distinct commodity-oriented institutes, thus addressing a set of research questions that (i) could credibly be presented as an acceptable proxy for eco-regional problems, (ii) could be approached more easily by following the CGIAR's

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approach. These experiences demonstrate that the prescriptions of the 'pipeline' model do not always lead to effective innovation. Rather, they suggest that while 'pipeline'-type institutions may be an effective means of generating innovations that address well-defined problems, such institutions are less successful in responding to 'messy' problem-situations where the parameters are poorly defined.

The above generalisation, if valid, has profound consequences. It should be clear that whenever the task of innovation involves responding to consumer demand, the problems addressed are virtually always 'messy' and poorly defined. This is because the needs of a heterogeneous set of consumers will depend upon a wide range of factors and are therefore likely to vary and to change over time. In particular, the second chapter considered some approaches to the closely related problems of poverty among rural people and of environmental degradation in areas of low resource agriculture. The most promising of these approaches involved research that responded to the demands and priorities of local people and acknowledged the trans-disciplinary complexity of the problems that it addressed. The argument of the preceding paragraph is that the framework provided by 'pipeline'-type institutions is spectacularly inappropriate for research of this nature. This means that when the major international donors adopted policies that stressed the need for sustainability, the CG system, which traditionally had virtually exemplified the 'pipeline' approach to innovation, was arguably the worst possible instrument to implement these new policies. However, the CG system was itself changed by the new emphasis given to environmental concerns. I shall return to this point in the next section.

The experiences analysed in the third chapter help to explain why the problems of poverty and environmental degradation presented by low resource agriculture are unlikely to be well-defined. The realisation by some of CIAT's commodity specialists that they could not ignore the *context* within which commodity production took place marked a growing awareness of the need for additional research, undertaken at a level of complexity higher than that of the discrete commodity. Such research was perceived as being important in facilitating the development of sustainable farming systems, so that from the beginning the need to define and investigate systems of interest that constitute contexts for commodity production was linked to environmental concerns. Indeed, the sustainability of an agro-environment is associated with a range of emergent properties that manifest themselves at

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different levels of complexity but depend upon the evolution of the agro-environment's components. Nor is this all: the evolution of these components, and thus the sustainability of the total agro-environment, depends upon the choices made by a number of (perhaps diverse) people, each with their own preferences and aspirations. It follows that, if sustainability-oriented research is to be effective, it needs to define its system of interest to include those people who are stakeholders in the agro-environment under consideration. Such stakeholders are likely to constitute a heterogeneous group, whose choices are informed by values that vary widely and are subject to change, and are therefore not capable of precise *a priori* definition.

The conclusion that the prescriptions of the 'pipeline' model are not applicable to poorly defined problem-situations such as those presented by low-resource agriculture adds urgency to the quest for a more satisfactory theory of innovation. Progress towards this goal has been made by members of two distinct traditions. The first of these, reviewed in Chapter 1, developed the 'fifth generation' model of innovation on the basis of their research on technology-based industries in developed countries. The second of these traditions, considered in Chapter 2, developed a model of 'new professional practice' as a set of prescriptions for making research more responsive to the needs of people in areas of low-resource agriculture. Despite the very different origins of these two traditions, and their isolation from each other (I have not encountered a single instance of a member of one tradition citing works from the other group), they agree that effective innovation is characterised by three fundamental principles. These may be stated as follows:

1. useful 'applied' knowledge is not usually derived from more fundamental knowledge but is generated *in the context of application*, a context that is provided by close links between researchers and practitioners;
2. continuous negotiation among stakeholders and researchers, in order to find compromises between what the different stakeholders want and what is technically feasible, is an essential part of the process of innovation;
3. *effective innovation requires new configurations of knowledge and skills*. The same set of specialist technologies and skills may repeatedly be configured in different ways to meet the (changing) needs of (varying) users, so that "the emphasis is on interdisciplinary teams with the maximum sharing of information across functions" [Rothwell 1992 p225].

The first chapter concluded that these 'fifth generation' principles represented a new definition of 'best practice' for innovation. The second chapter then argued that a 'new professional practice' based upon these principles is required if researchers are to deliver technologies that are relevant to the problems of low resource agriculture. Both chapters noted that this new style of working had clear organisational implications. This posed the question of how easy it would be for an innovation-oriented enterprise that had been organised on the basis of the 'pipeline' model to work in a 'fifth generation' manner. The empirical material presented in the remainder of this thesis illustrates the difficulties that may face such an attempt.

Institutional change

Using Formal Authority

One approach to the problem of transforming institutions was demonstrated by the actions of the donors to the CG system. They used their control over the financial resources upon which the System depends to compel the IARCs to undertake research focused upon the objective of environmental sustainability. In effect, they were requiring a set of 'pipeline'-type institutions to achieve objectives that (as argued above) could only be achieved by working in a 'fifth generation' manner. The donors sought to implement this new policy by (i) setting new research objectives for the IARCs, and (ii) catalysing structural change to the CG system as a whole: a number of 'free-standing' research institutes, whose activities were focused upon goals related to sustainability, were added to the CG system. However, the donors were not in a position to build a consensus in favour of their new policy among the practising researchers who would have to implement it. Nor could they act directly to effect any changes to the internal structure, working practices and organisational culture of individual Centres. The task of making such changes as were necessary remained the responsibility of the staff of the Centres affected.

How effective is this approach to organisational change likely to prove? Chapter 3 discusses, at the level of an individual Centre, the changes that resulted when the new policy was implemented in this way. Again, the reforms outlined in the 1991 Strategic Plan were implemented, not because there was a consensus favouring such change among CIAT's scientists, but simply because the Director General used his authority to over-ride

opposition from his staff. While the Plan indicated that changes in methods of working were a pre-condition of meeting the environment-related concerns expressed by donors, the reforms that it outlined did not act *directly* upon the professional practice of the Centre's staff, nor upon the style of innovation that this produced. Instead, they concentrated upon structural change at the level of the Centre. New Programmes, with new objectives, were to be added to the Centre, while new goals were set for all four of the existing Programmes. While these reforms were undertaken at the level of the complete Centre, they did result in some changes within its components, the Programmes. It is instructive to consider the extent to which these changes represented movement towards the 'fifth generation' model.

The effects of the reforms were most obvious in the four (later two) Programmes that were created in the new Resource Management Division. Although the Commodity Programmes did not experience structural change⁷¹, they responded to the reforms by revising their objectives and went on to develop an impressive range of research projects related to the management of renewable natural resources. Both the achievements and the limitations of these projects serve to demonstrate the extent to which change is possible in the style of innovation pursued within the framework of a Commodity Programme.

Resource Management Research in the Commodity Programmes

The character of these projects reflected both the structure and the underlying assumptions of the Commodity Programmes within which they had been conceived and nurtured. Their focus therefore remained upon the crop with which the host Programme was primarily concerned, rather than upon the ecosystem within which the crop was grown. The objective of this work was to manage the immediate surroundings of the crop so that the germplasm developed by productivity-oriented research could realise its full potential. And crop yield was still assumed to be the primary objective to pursue: indeed, the Leader of the Bean Programme saw the purpose of NRM work as being to ensure that "a higher yield is sustained through better management of the environment". One result of these assumptions was that the research projects based upon them tended to be at the scale of the plot, rather than that of the landscape or even that of the individual farm.

⁷¹ Note, however, that the old Pastures Programme lost its soil scientists and was renamed the Tropical Forages Programme.

The systems of interest addressed by these research projects were thus defined at a level of complexity that constituted an immediate context for commodity production, but which was too low to capture many emergent properties of relevance to NRM. Furthermore, the boundaries of these systems of interest excluded the rural people whose values and aspirations would (as argued above) determine the manner in which the resource in question would actually be managed. These projects (including the collaborative development of 'prototype' rice-pasture systems for the savannahs) thus concentrated on the quest for technical solutions to the problems that were apparent to the Programmes' scientists. In some cases they did involve work with farmer participation, with building community organisations and with modifying local-level institutions, but all of these activities followed the development of technical solutions and were directed at finding ways to make them work. Mechanisms that would have enabled stakeholders to influence the research agenda were less evident in any of these projects.

The new emphasis placed upon natural resource management did not, therefore, result in a material change in the model of innovation practised by these Programmes. Rather, they pursued the new objectives in a manner consistent with their earlier approach to innovation. In particular, the exclusion of rural people from their systems of interest meant that there was little or no scope for these stakeholders to take part in negotiating the definitions of the research questions to be addressed and hence the design of the innovations that resulted from this process. The Commodity Programmes thus continued to practise their tradition of relative isolation from their stakeholders, despite Centre-level policies that sought to promote greater collaboration with stakeholders external to CIAT. This tradition of isolation was rooted in the CGIAR's conventional wisdom, which held that scientists could work most effectively when they were protected from 'political' pressures and free to get on with the job of developing valuable new technologies. Underlying this view was the assumption, long held within the Rockefeller Foundation and the institutes that it spawned, that "new technology is the key leading factor in the process of desired social change" [Anderson *et al* 1991, p31]. Formal authority, even that of the Director General himself, had proved insufficient in itself to transform such a long-established approach to innovation, rooted as it was in many other aspects of organisational culture.

Experiential Learning

The work of the Hillsides Programme (discussed in Chapters 4 and 5) represented a different approach to the task of transforming the model of innovation practiced by CIAT. Rather than *telling* people to work in a manner different from that to which they were accustomed, the leadership of this Programme sought to *involve* a selection of CIAT scientists in an effective piece of 'fifth-generation' innovation. Such involvement, it was believed, would expose collaborating scientists to a range of experiences incompatible with their prior assumptions, thus catalysing a learning process that could lead them to adopt aspects of the 'new professional practice' (see Chapter 2). The capacity to undertake 'fifth generation' innovation was thus seen as one important product of working in this way.

In effect, the work of the Hillsides Programme represented an attempt to work in a 'fifth generation' manner by one component of an institute that was predicated upon the contradictory 'pipeline' model. The relationship between this component and the whole institute was thus important in determining the degree to which the objectives of the project were realised.

The Hillsides Programme: a 'fifth generation' initiative in a 'pipeline'-type setting

The work of the Hillsides Programme (Laderas) was strongly influenced, and to some extent frustrated, by CIAT's Centre-level characteristics and policies. The capacity of Laderas to modify its organisational environment (CIAT) was rather more limited. This whole experience (considered in more detail in Chapter 5) demonstrates the capacity of an organisation to constrain initiatives that take place within itself when such initiatives run counter to the established working practice of the wider organisation. Conversely, a component of an organisation has little power to modify the wider organisation.

Laderas owed its existence to CIAT's structural change of the early 1990s, and so its original workplan (see Chapter 4) was designed to be consistent with the Centre's 1991 Strategic Plan. Two of the themes considered by this Plan proved particularly important in guiding the work of Laderas. The first of these was the realisation that a positive response to the new sustainability-related agenda would require "an increase in our associations with others who have different comparative advantages" [CIAT 1991, p20]. The Plan therefore

stressed the importance of working in collaboration with bodies outside CIAT through the development of consortia and strategic alliances. This Centre-level policy statement represented a departure from the earlier 'pipeline' model of innovation, which had emphasised "building a center of excellence ... at the international level [while national] and other partners played a partially receptive role" [*ibid* p25], towards the 'fifth generation' approach.

A similar line of argument led the Plan to acknowledge that the diversity of the hillsides ecosystem meant that technical solutions would require local-level adaptation to meet location-specific conditions. The Laderas workplan, which was prepared by people with substantial experience of facilitating farmer participation in the research process, developed this insight by stressing the role of rural people in the management of their resource base. The primary thrust of the planned research was thus the development of methodologies for building institutions through which local people would be able to negotiate and implement a management plan for their environment. Such institutions would also exert demand for whatever new technologies would be necessary for the management plan to be implemented, so a second thrust of the planned research was the development of the required technologies. The Laderas workplan thus aimed to involve the users of new technology in its development, and so represented a significant departure from the 'technology-first' paradigm within which the IARCs had carried out most of their research, again in the direction of the 'fifth generation' model.

Although the staff of Laderas drew up their workplan in the expectation that a new team would be formed to implement it, CIAT's subsequent financial crisis made it impossible to recruit the necessary new staff. The Centre's Board therefore decided that members of the existing staff, drawn from various established teams, should devote part of their time to implementing the Laderas workplan. In the language of Chapter 1, this decision represented a change from *inter-disciplinary* to *trans-disciplinary* research. The issues that it raised were profound, although it is not clear that this was appreciated at the time: while the CG System (including CIAT) had considerable experience of successful inter-disciplinary work, trans-disciplinary research demanded new management and incentive systems and a cultural change. The significance of this point will be explored below.

The work of Laderas, as discussed in Chapter 5, thus conforms to the 'fifth generation' model of innovation presented in the conclusion to the first Chapter. Laderas, however, remains part of CIAT, an organisation whose structure and culture are predicated upon the 'pipeline' theory of innovation. This wider organisation naturally conditioned Laderas' activities, which to some extent were frustrated by the contradiction between the two approaches to innovation.

Contradictions between CIAT and Laderas

The most obvious contradiction concerned the applicability of Laderas' research to other contexts. CIAT, as a member of the CG System, was mandated to produce technologies with a broad agro-ecological application. These were expected to take the form of generic knowledge that could be used by the national programmes of individual countries in their own more location-specific technology development activities. Laderas, however, was conducting research in the context of application, building local-level institutions within a particular watershed. The main benefits of this work, at least in the first instance, would be felt by the immediate region served, prompting the suggestion that it was a location-specific development project and therefore fell outside the mandate of an International Centre. Laderas' leadership were therefore forced to justify their work in terms of the opportunities that it would offer for developing "a strategic understanding of *how* to intervene in a hillside agro-ecosystem" [CIAT 1993 section 1.3]. Thus, they described their work as first building a "working experimental model of sustainable agricultural development for the hillsides" [*ibid*] and then identifying "principles for making the model self-sustaining; and for replicating it in similar ... environments" [*ibid* section 1.4]. In effect, they had been forced to justify one aspect of the 'fifth generation' model of innovation in terms of the 'pipeline' model. Donor support was important in persuading CIAT's administration to accept this argument and allow the project to proceed.

Implementation of the Laderas workplan was hindered by another of CIAT's Centre-level characteristics: the policy that all Programmes should work in collaboration with external bodies through the development of consortia and strategic alliances. Ironically, this policy reflected the acceptance of some aspects of the 'fifth generation' model by CIAT's management, but its application to the work of Laderas proved inappropriate. It obliged Laderas to work in close collaboration with a range of external bodies, many of whom

neither understood nor shared the objectives that Laderas saw for the project. As a result, the objectives of the project changed between conception and execution, with Laderas' original objectives being absent from the project that was implemented.

The consequences of inappropriate collaboration may be seen by considering Laderas' efforts to accomplish the primary task that it faced in implementing its workplan: that of building institutions to promote landscape-scale environmental management. These institutions were also seen as being a means to develop community-based capacities to exert effective demand for resource-conserving new technology. The primary institution to be formed was a Watershed Users' Association, which was to be developed as a forum for negotiation between different interest-groups about resource-management issues within the watershed. As argued in Chapter 4, the interdependence that exists between different users of a watershed meant that this Association could only function effectively if all relevant interest-groups were properly represented in the negotiations held within it. Laderas, however, was unable to ensure that this condition was satisfied, and therefore could not prevent the Association from reproducing the existing structure of local power. The pressure upon Laderas to collaborate with external bodies, even when the meaning of the project was not shared, is important in explaining this failure.

For the reasons discussed above and in Chapter 4, Laderas needed to form consortia to share its projects, rather than working on its own. Therefore, instead of working independently with the people of the watershed, Laderas first forged links with the other (external) agencies that were already working there. Only later, once these agencies had reached agreement on a common programme of action and had formed a consortium (known as CIPASLA) for its implementation, did work begin on organising the Watershed Users' Association, and this task was now shared with the other members of CIPASLA. Furthermore, the agenda agreed for CIPASLA by its members was organised around the fundamental objective of protecting water sources. This objective reflected the demand, made by a group of community leaders from parts of the watershed affected by water shortages, that CIPASLA support their campaign to protect their water supply and thus its sources in the upper part of the watershed. This group of local leaders had been able to use their experience of organisational processes to secure a set of projects from CIPASLA that would respond to their concerns.

The task of organising the Watershed Users' Association was thus undertaken by a consortium whose agenda was focused upon the protection of water sources. Indeed, the meetings at which the nascent Association was introduced to the communities of the watershed formed part of the motivational campaign that was conducted by a group of local leaders concerned about this issue. During these meetings, they defined the purpose of the Association as the protection and regeneration of the water supply, and also held elections for the representatives who would participate in the constituting meeting of the Association. Since this water-focused agenda was only relevant to some of the many interest-groups present in the *cuenca*, the members of the remaining interest-groups were effectively excluded from participation in the Association. Finally, the same group of local leaders used the inaugural meeting of the Association to define the basis for membership as representation of the various organisations and interest groups within the watershed. Since these groups tended not to receive the participation of poorer people, they represented essentially the same interests as did the group of leaders. This group of leaders thus ensured that the Association would reproduce the existing structure of local power. Clearly, they saw this initiative as a means to resolve their concerns about water sources, and did not share the meaning attached to it by Laderas.

The context within which the Watershed Users' Association was formed thus prevented it from articulating an agenda that reflected the needs of the various stakeholders in the *cuenca*. Laderas' strategy, however, depended upon achieving this goal so that it could then work to develop the technologies necessary to implement the Association's agenda. A reasonable response might have been to concentrate upon work with the Association until it did begin to exert effective demand for technology. However, work on institution-building and community organising lay on the margin of the range of research activities that CIAT as a whole regarded as legitimate concerns for its Programmes. Laderas therefore needed to demonstrate that it was pursuing an agenda that, on the whole, lay within the definition of legitimate research that was generally accepted by the Centre and more broadly by the CG System. Accordingly, work on the second thrust in the Laderas workplan, the development of technologies to meet the needs articulated by the stakeholders in the *cuenca*, began as a response to pressures within CIAT, even though the Laderas staff were aware that the Association was not yet effective in articulating these needs. These efforts to develop

technologies in the absence of user demand represented a step away from the 'fifth generation' model, back to the 'pipeline' model with which CIAT was more familiar.

The leadership of Laderas were, of course, aware that the conditions that they had regarded as prerequisites for the second thrust of their workplan were not yet entirely fulfilled. In particular, it was clear that the institutional mechanisms that had been intended to set the objectives of this second thrust were not yet functioning. However, Laderas believed that the objectives of the project would evolve as progress was made, so that it would eventually meet many of their original expectations. They believed that this evolution would result from the scientists involved undergoing a series of learning experiences in the course of implementing the project, and modifying the objectives pursued as their assumptions changed. Indeed, the Laderas leadership hoped that the scientists involved would apply their new insights to their work for other parts of CIAT. In this way, it was hoped that the Inter-Programme Project would catalyse profound changes across the whole of CIAT.

Efforts by Laderas to reform CIAT: the plan

Laderas' leaders, at least to some extent, saw the Inter-Programme Project as a means to change CIAT. They believed that involvement with this project would expose collaborating scientists to a range of experiences incompatible with their prior assumptions, thus catalysing a learning process that could lead them to transfer their cognitive allegiance to the 'fifth generation' practice. This learning process was expected to take place as they interacted with the people of the watershed and learned more about their objectives and experimentation; as they interacted with Laderas' staff and learned more about the social research that provided the context for the bio-physical research in which they were engaged; and as they interacted with each other, bringing their different professional perspectives to bear upon shared problems. In other words, they expected each of the scientists involved to develop a deeper appreciation of the *meaning* of the project through interaction with others involved. This collective learning, seen as being valuable in itself, was one (tacit) objective of the project and was expected to result in a broadening and development of the project itself. One important product of undertaking a project predicated upon the 'fifth generation' model would thus be the capacity to work in this way.

How realistic were these expectations? The final part of Chapter 1 argued that these processes of information sharing and collective learning, which are fundamental to the practice of 'fifth generation' innovation, require favourable conditions if they are to take place to the extent necessary for effective innovation. This argument referred to Quinn *et al* [1996], who observed that professionals may be reluctant to share the knowledge that constitutes their most precious asset, while "the tendency of each profession to regard itself as an elite with special cultural values may get in the way of cross-disciplinary sharing". Conversely, these authors suggested that "[m]any professionals have little respect for those outside their field, even when all parties are supposedly seeking the same goal" [*ibid* p75] and so are reluctant to learn from people outside their own profession. They suggested that strong inducements were necessary to overcome the barriers to this kind of learning, and presented empirical evidence in support of this recommendation. They concluded from this evidence that changes in the ways in which performance is measured and rewarded were vital if the desired behavioural changes were to take place. "Without such changes [we found that people] continued to perform according to the traditional measures." [*ibid* p78] They noted, however, that this kind of change was significant for the organisation as a whole and therefore required an initiative from senior management. Support for this view is provided by Rothwell [1992], who argues that innovation may require organisational change, and that management acceptance of this requirement is important for successful innovation.

Even in the presence of favourable conditions and appropriate incentives, the transition to 'fifth generation' innovation practice is unlikely to be easy. An indispensable element of this practice is that the various experts and stakeholders interact sufficiently for the members of each group to grasp the different *meanings* that the project holds for the others involved. However, as Quinn *et al* [*op cit* p79] point out: "How groups communicate and what they voluntarily communicate are as important as the knowledge [to which their members have access]. For virtually all purposes, however, encouraging shared interests, common values, and mutually satisfying solutions is essential for leveraging knowledge in these structures." This observation underlines the importance of understanding how these essentially inter-personal processes may be facilitated effectively, and of applying this understanding to developing the capacity of innovating enterprises to facilitate this kind of interaction. In the absence of relevant skills in facilitating the creation of shared meanings in

trans-disciplinary groups, there is a real risk of meetings resulting in little more than a series of frustrating misunderstandings.

Therefore, Laderas' strategy for reforming CIAT depended upon the learning process that collaboration with the Inter-Programme Project would provide for the scientists involved. In turn, this learning process depended upon the quality of their interactions with the members of different groups, people whose viewpoints would call into question the assumptions held by the scientists. The above discussion suggests that the quality of this kind of trans-disciplinary interaction itself depends upon the organisational conditions under which it takes place: these include factors such as the presence (or absence) of strong incentives to share ideas with people outside their own specialism; the manner in which the specialists define their roles; the availability of facilitation skills to manage this kind of interaction effectively. Organisational factors such as these would thus determine the success of the attempt by Laderas to reform its organisational environment. Indeed, it is probable that a similar set of factors determine the capacity of any organisation to learn.

Efforts by Laderas to reform CIAT: implementation

The mechanism by which Laderas hoped to modify CIAT was a collective enterprise known as the Inter-Programme Project. By involving staff from different parts of CIAT in an effective 'fifth-generation' innovation project, Laderas hoped to catalyse widespread questioning of the assumptions linked to the 'pipeline' approach. This project, as conceived by Laderas, constituted a component of a wider initiative that exhibited all three of the defining characteristics of 'fifth generation' innovation. The argument of the preceding section suggests that certain organisational characteristics that are compatible with 'fifth generation' innovation are necessary if this kind of initiative is to succeed. However, CIAT as a whole did not satisfy this condition, since the Centre was organised in a manner more consistent with the 'pipeline' model of innovation than with the 'fifth generation' model. CIAT's cultural and organisational characteristics therefore constrained the implementation of the Inter-Programme Project (IPP): those aspects of the IPP that most clearly differentiated it from projects predicated upon the 'pipeline' model proved particularly vulnerable. This was already apparent in the 'planning by objectives' (PPO) session with which the implementation of the IPP began.

This session was held within the Centre, and only CIAT staff took part: neither CIPASLA nor the people of the *cuenca* were directly represented, although information on their stated needs was given to all participants in the PPO. Most of the participants in this session had been chosen on the basis of their contribution to the development of prototype systems for the savannahs, which was widely seen as representing a paradigm for CIAT's research on natural resource management. This paradigm, it will be remembered, involved researchers working without any farmer inputs to design a 'best bet' system: the farmers' role in the research was confined to their decision to adopt the new technology once it had been developed for them. Despite the fundamental differences between the hillside and savannah ecosystems, no-one present at the PPO was in a position to question the validity of this paradigm as an approach to resource management in the hillsides. The IPP thus became a display of 'best practice' from the Lowlands and other Programmes at CIAT, a display which did not use many of the insights of local farmers, ultimately because there had been only limited interaction between farmers and scientists at the time the trials were planned. The design of the new project thus reflected the assumptions and experience of those present at the PPO and lay within a 'technology-first' paradigm which conformed closely to the prescriptions of the 'linear' model.

Nor did the IPP show any early signs of development away from the paradigm established by the work in the savannahs, despite the hopes of such development that were cherished by Laderas' leadership. Several factors are relevant to explaining this disappointing outcome: the weakness of the demand for new technology; the manner in which the majority of the scientists involved defined their roles; the general lack of group facilitation skills; and the way in which the performance of CIAT scientists is evaluated and rewarded.

As discussed in Chapter 4, the construction of a set of institutions that would develop community-based capacities to exert effective demand for technology had been fundamental to the original project design. Mechanisms such as the Innovators' Workshop and the Participatory System Trials had been intended to mediate a specific kind of farmer-scientist dialogue: their absence therefore reduced the *quality* of the interaction that took place between these two groups and thus limited the scope for mutual learning.

Conclusions

At several points in Chapter 5, evidence was presented that many of CIAT's bio-physical scientists were reluctant to address questions that transcended their own area of expertise, instead tending to expect others to define technical problems for them to address. Such tendencies, it is clear, represent a definition of the role of the scientist that is in direct conflict with the requirements of 'fifth generation' innovation. While the strength of these tendencies varied between different individuals, there can be little doubt that they were aggravated by the lack of people with skills in facilitating the creation of shared meanings in trans-disciplinary groups. Such skills are vital if a group is to work in a 'fifth generation' manner, but there is no evidence that the need for them has even been considered by the Centre's management. Instead, the evidence demonstrated that the movement of individual scientists towards a 'fifth generation' practice was inhibited by the Centre's Programme-based culture and by the way in which it evaluates and rewards the performance of its scientists.

The Centre's processes for measuring and rewarding the performance of its scientists remain shrouded in mystery, as do the criteria upon which these processes are based. However, the scientists interviewed believed that the evaluation of their work depended mainly or entirely upon the report written by their respective Programme Leader; that this report was almost exclusively concerned with their contributions to their own Programme and thus did not consider their work for inter-Programme activities; and that the evaluation would give far more credit for immediate research results than for activities intended to produce more significant results in the future. Such a regime clearly encouraged them to devote most of their effort to work for their own Programme while minimising the time consumed by other activities such as the Inter-Programme Project. More fundamentally, the value that was placed upon producing research results within a limited time-scale discouraged any movement away from the traditional role of the specialist in a particular field who solves technical problems within parameters defined by others. Time devoted to 'fifth generation' activities, such as interacting with other kinds of stakeholder in the project, would inevitably reduce the amount of time available for solving well-defined technical problems and thus generating research results.

It is clear, then, that CIAT's system of staff evaluation acted to hinder progress towards the 'fifth generation' model of innovation, instead helping to confine scientists to a more

traditional role. Moreover, any move to remove these 'perverse incentives' would involve reducing or diluting the power of the Programme Leaders. A change such as this could only be effected with support from the highest level of management. Again, this observation is consistent with Rothwell's discussion of the role of product champion (more generally, innovation champion). After conducting a comprehensive review of empirical research on the process of innovation, Rothwell concluded that while "[the] presence of effective product champions is strongly associated with innovatory success", their endeavours within hierarchical organisations were often ineffective unless they had "sufficient power and authority positively to influence the course of the project and 'push' it across internal barriers to change" [*ibid* p226].

The experience of CIAT's Inter-Programme Project thus demonstrates that effective implementation of a change in the style of innovation practised by an organisation requires a wide range of changes at different levels of the organisation. This finding both confirms and amplifies the observation that "technological innovations might require organisational and marketing innovations to facilitate their implementation" [Rothwell 1992 p227].

Organisational change, however, is likely to modify or disturb the power relations that prevail between those affected by the change, and is therefore likely to be resisted by those whose authority would be diminished. Initiatives enjoying strong leadership at the level of the project team are necessary if a new style of innovation is to be practiced, but such initiatives require sustained support from the highest levels of the organisation if resistance to the wider changes that they make necessary is to be overcome.

The Future of the CGIAR

The reasons for the inability of the CG System to respond adequately to the new priorities of its donors should now be clear. Quite simply, the research agenda that is now being set by these donors can only be addressed effectively by organisations whose essential characteristics differ in important respects from those that the Research Centres of the CGIAR have displayed throughout their history. Nor do the donors have access to the organisational 'levers' that could perhaps be used to effect change in the relevant characteristics of the IARCs. This dilemma requires a range of apparently contradictory responses.

Firstly, the donor community should cease 'punishing' the CG System for not being something that it is not. To the extent that they recognise the continuing value of the commodity-focused research at which the IARCs excel, they should maintain their support for the core budget of the CGIAR. Such support should take the form of long-term funding commitments: the empirical parts of this thesis demonstrated the enormous waste and long-term damage that result from budgetary fluctuations and from their attendant uncertainties.

Decisions concerning the level of such support should be informed by the material presented in Chapter 5, which demonstrates that commodity-focused expertise in the agricultural products of an ecosystem is an important component of any 'research system' formed to address the management of renewable natural resources in that ecosystem. Limited but consistent support for the core funds of the CGIAR is likely to prove a cost-effective means of maintaining this expertise, the value of which includes (but is not limited to) its potential contribution to environmental research. Of course, this does not mean that the Commodity Programmes of the IARCs are, in themselves, appropriate organisations for undertaking eco-regional research: this is clearly not the case. Rather, they are in a position to make an important contribution to the work of the 'eco-regional entities' to which the bulk of donor support for resource-management research should be directed. In other words, the traditional IARCs can contribute most effectively to environmental research in the role of sub-contractor rather than that of prime contractor. One unfortunate consequence of the donors' failure to recognise this has been the growth in 'complementary' funding of the IARCs, which has led them to attempt tasks that they are not equipped to undertake at the cost of neglecting what they do best. The scale of such complementary funding should

therefore be reduced considerably, and care should be taken that support is given only for work that the recipient IARC is capable of undertaking effectively.

Secondly, the donors should give their active support to initiatives that promise to build the capacity for 'fifth generation' innovation within the CG System. Such support should take the form, not only of finance, but also of a continual readiness to approach the most senior management of the Centre in question to discuss the organisational and political difficulties that will inevitably be experienced by an initiative of this kind. As we saw in Chapter 5, Centre-wide systems of authority and accountability (underpinned by the Centre's established power structure) may well act to stifle this kind of initiative unless it receives active support from the most senior levels of management.

While the support of donors and senior management is almost certainly a *necessary* condition for such an initiative to be effective, such support is unlikely to prove *sufficient*. This is because the majority of the changes that are involved in the transition to a new mode of innovation will take place, if at all, at the level of the project team rather than at that of an entire Centre. Quite what changes are involved, and the ways in which they may effectively be promoted, remain unclear. However, the experience of Laderas' efforts to practice the 'fifth generation' suggests that any project team which is effective at working in this manner will display the following characteristics:

- ♦ It will comprise specialists from a *range* of cognitive backgrounds (to match the variety of the system under investigation), but all of its members will share a common vision of the meaning and direction of the project. There can be little doubt that strong, inspiring leadership is required to instill and to sustain such a vision. In addition, specialist skills in facilitating collective learning and communication between members of differing intellectual traditions are necessary if the team is to attain a shared understanding of the task in hand. The IARCs, as a matter of urgency, should recruit people with these skills, and should monitor carefully the effectiveness of the various approaches employed by them. In this way it should eventually be possible to develop a set of general guidelines for facilitating the formation of effective trans-disciplinary teams;

Conclusions

- ♦ It will include social scientists equipped with the skills normally associated with Anthropology. Such skills (at the level of the project team) are absolutely indispensable for a range of tasks that are essential to the practice of 'fifth generation' innovation relevant to the rural areas of the developing world. These tasks include defining the social groups that are stakeholders in the innovation pursued, identifying possible conflicts between the interests of these various groups and guiding the choice of group(s) whose interests are to be given priority. Further, since the 'fifth generation' model emphasises the importance of negotiation between technologists and their clients, the skills of an anthropologist are vital, both for eliciting information from the primary stakeholders concerning their objectives and strategies, and for experimenting with institutional frameworks that can provide an effective context for such negotiation. Such experimentation should be informed by a greater acceptance of the agency of the rural poor than has usually characterised the work of the CGIAR.

It is therefore of the first importance that the IARCs not only experiment with different methods of implementing 'fifth generation' innovation but also ensure that they learn whatever lessons these experiences may hold. If the IARCs succeed in conducting such 'action research' upon themselves, the results are likely to prove of great value to all of their stakeholders, and particularly so to the National Programmes, their immediate clients.

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